Technical Report 860

# Training Procedures for Enhancing Reserve Component Learning, Retention, and Transfer



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September 1989

**United States Army Research Institute for the Behavioral and Social Sciences**

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This report summarizes the results of an extensive literature survey conducted to provide the U.S. Army National Guard and Reserve, i.e., the Reserve Component (RC), with practicable information on how to train for enhanced soldier performance. General training procedures or strategies are recommended for improving the learning, retention, and transfer of verbal and perceptual motor skills. When incorporated by the military training developer and applied on a task-by-task basis by the RC trainer, these general procedures will help to ensure maximum payoff from the training resources invested. (Keywords)

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## FOREWORD

Summarized in this report are the results of an extensive literature survey examining training procedures known to enhance the learning, retention, and transfer of verbal and perceptual-motor skills. The report was written to provide the U.S. Army National Guard and Reserve, i.e., the Reserve Component (RC), with practicable information on how to train for enhanced soldier performance.

The review was conducted by the Training Technology Field Activity--Gowen Field (TTFA-GF), whose mission is to improve the effectiveness and efficiency of RC training through use of the latest in training technology and procedures. The research task supporting this mission is entitled "Application of Technology to Meet RC Training Needs" and is organized under the "Training for Combat Effectiveness" program area.

The National Guard Bureau (NGB), Office of the Chief, Army Reserve (OCAR), and U.S. Army Training and Doctrine Command (TRADOC) sponsored this project under a Memorandum of Understanding, signed 12 June 1985, establishing the TTFA--GF. The contents of the review have been presented to Chief, Training Support Branch, NGB; Chief, Training Division, OCAR; and Director, Training Development and Analysis Directorate (TDAD), TRADOC.

Edgar M Johnson

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Technical Director

TRAI' G PROCEDURES FOR ENHANCING RESERVE COMPONENT LEARNING, RETENTION, AND TRAN R

EXECUTIVE SUMMARY


Requirement:

Provide the U.S. Army National Guard and Reserve, i.e., the Reserve Component (RC), with a review of past research that identifies specific training procedures for enhancing the learning, retention, and transfer of military skills.

Procedure:

The review was accomplished using prior reviews of the behavioral, information processing, cognitive, educational, and military training literature, as well as original research reports found in major documentation sources such as the Defense Technical Information Center, National Technical Information Service, Educational Resources Information Center, and Psychological Abstracts. The effects of a broad range of general training procedures or strategies applicable to the unique RC training environment are discussed. Many of the conclusions are based on the results of both basic (laboratory) and applied (field) research and are somewhat oversimplified to promote understanding and application. These constraints notwithstanding, a number of general conclusions can be made.

Findings:

1. Pretraining procedures that incorporate the use of pretests, behavioral objectives, overviews, or advance organizers enhance the learning process. Pretests alert, behavioral objectives inform, overviews prepare, and advance organizers clarify. All give direction and purpose to learning through their introductory or anticipatory role and provide an overall learning set for what is to follow.

2. Once training begins, repetition is necessary to achieve proficiency on all but the simplest of verbal and perceptual-motor tasks. Providing additional repetitions beyond those necessary for achieving minimum task proficiency will promote further learning, increase retention, and reduce the need for frequent refresher training. Transfer will also improve as the number of repetitions is increased, especially when task variety is emphasized.

3. Retention of verbal tasks is better when repetitions are spaced (e.g., separated in time) than when they are massed (e.g., performed in succession without an intervening time interval). Benefits from spacing increase as the interval between repetitions increases, provided this interval is not excessive.

4. Massed and spaced repetition schedules seem to have about the same beneficial effect on the retention of perceptual-motor tasks. Spaced scheduling is particularly recommended for (a) dangerous tasks where fatigue could pose a safety risk, (b) poorly motivated trainees who are adversely affected by the rigorous nature of massed repetitions, and (c) high-ability trainees who tend to make more responses during massed scheduling, quickly become fatigued, and accordingly respond at a lower level of proficiency than trainees of lower ability. The need for additional training time under a spaced repetition procedure can be eliminated through the process of task alternation.

5. Mental practice is effective for learning both verbal and perceptual-motor tasks. For the latter, the most effective procedure probably involves a combination of both physical and mental practice. Benefits from mental practice are more likely to occur early in training when verbal-cognitive processes are most involved, but also can occur later or when trainees are more capable of conceptualizing responses mentally. Mental practice sessions should be kept brief (e.g., 5 min or less) in order for trainees to maintain effective concentration.

6. Benefits derived from repetition can be enhanced if trainees also intend to learn the task. This intent should be present before training starts and can be established by (a) assisting trainees in setting performance goals, and (b) indicating the future utility of the task to be learned.

7. Knowledge of results (KR) is essential for achieving effective learning, retention, and transfer. The benefits of providing KR depend upon the (a) length of time passing between a response and receipt of KR, (b) amount of time passing between KR and the next response, (c) precision of KR, (d) frequency of KR, and (e) if and when KR is withdrawn during training.

8. The more response-produced feedback (i.e., sensations accompanying a response) provided during training, the more accurate and confident trainees' responses will become. The most important feedback channel is vision.

9. Providing augmented feedback (i.e., artificial cues not normally associated with response production) improves performance and speeds up training. These benefits, however, can be transitory and may not persist once the cues are removed unless an adaptive withdrawal procedure is used wherein augmented feedback is given only when responses exceed a specific error limit or significantly deviate off course.

10. Guidance during training (e.g., in the form of telling or physically showing trainees the correct response) will promote quicker and more accurate learning of the specific task being trained. In contrast, encouraging trainees to discover the correct response on their own, usually through a process of trial and error (with KR), typically promotes better transfer of learning from one task to another. Training that initially provides guidance at the start and then switches later on to discovery will promote effective learning, retention, and transfer.

11. Testing should be emphasized during training to promote effective verbal and perceptual-motor task retention. The type of test used should reflect job conditions. Recall tests usually will support the discrimination

requirements of a recognition test, but recognition tests will not necessarily support the more stringent memory retrieval requirements of a recall test.

12. Questions should be asked within the context of the training materials to enhance learning and retention. Benefits achieved from asking questions will vary as a function of (a) their location in the text, (b) the kinds of questions asked, and (c) their format.

13. Learning and retention increase when trainees are required to elaborate on the materials to be learned. Elaboration can take the form of adding related background information, imagery, or any kind of symbolic structure to the training materials for the purpose of making them more memorable. A common form of elaboration involves the use of mnemonics. Mnemonics are most effective when the material to be learned is concrete (easily imagined), and when it is not easily learned through rote repetition. Although mnemonic usage can improve retention, it often also increases the time required for training.

14. Positive transfer is likely to occur when similar elements (e.g., stimuli, responses, concepts, procedures, rules, etc.) are present in both the training and transfer task(s). The degree of intertask similarity will determine how much and what kind of transfer (positive or negative) is obtained with both verbal and perceptual-motor tasks.

15. Whole-task training is recommended for tasks that require continuity and coordination of their various parts, whereas part-task training is recommended for tasks that are difficult to perform and consist of independent parts or subtasks.

16. Transfer of verbal and perceptual-task learning increases with the variety of tasks (or examples) presented during training, provided that each task is sufficiently learned. Task variety should be presented in a random rather than a blocked order to promote maximum retention and transfer.

17. The time interval between the performance of successive tasks should be kept to a minimum to ensure effective transfer.

18. Providing a verbal description of a perceptual-motor response or movement will improve learning and retention, provided that the required response does not depend largely on precise proprioceptive regulation.

19. Refresher or sustainment training is an effective procedure for reinstating task proficiency levels and promoting long-term retention. The amount of time required for refresher training is typically less than that required for initial training but will vary as a function of the (a) length of the no-practice interval intervening between the end of initial training and the start of refresher training, (b) the frequency of prior refresher training sessions, (c) the temporal spacing of sessions, and (d) the type of task to be retrained. A method for predicting task retention and associated refresher training requirements is discussed in the body of the report.

20. Cooperative or small-group training is an effective procedure for improving individual trainee achievement, provided each group member is held individually accountable (i.e., tested) for his or her own learning and a

group reward contingency is enforced. Benefits from cooperative learning will be most pronounced with groups containing six or less members.

Utilization of Findings:

The present findings provide the RC with practicable information on how to train for enhanced soldier performance. The general training procedures or strategies that are recommended will enhance the learning, retention, and transfer of a wide range of verbal and perceptual-motor skills. When incorporated by the military training developer and applied on a task-by-task basis by the RC trainer, these general procedures will help to ensure maximum payoff from the training resources invested.

TRAINING PROCEDURES FOR ENHANCING RESERVE COMPONENT LEARNING, RETENTION, AND TRANSFER

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# TRAINING PROCEDURES FOR ENHANCING RESERVE COMPONENT LEARNING, RETENTION, AND TRANSFER

## Background

The Reserve Component (RC) of the U.S. Army must meet formidable training challenges in attempting to attain and maintain readiness levels comparable to those of the Active Component (AC). These challenges stem from the unique environment in which the RC must train. This environment is characterized by small, geographically dispersed units, shortages of mission-essential equipment, significant personnel and structural turbulence, restricted access to range and maneuver areas, and minimal time to train.

Of all these constraints, limited time is perhaps the most crucial. RC training time is about one fifth of AC training time and is distributed in discrete chunks over the calendar year, i.e., 24 days of Inactive Duty Training (IDT), normally conducted during one weekend per month, and 15 (Army National Guard) or 14 (Army Reserve) successive days of Annual Training (AT), usually conducted during the summer.

Because time is so limited, RC training must be as effective and efficient as possible. To this end, past research was surveyed to identify training procedures known to have a positive impact on soldier performance.

## Purpose and Scope

This report was written to provide the RC with a practicable information base from which to make decisions about how performance can be enhanced through the use of specific training procedures. Emphasis is placed on describing particular procedures or strategies that, when incorporated by the training developer and applied by the trainer, will substantially improve soldier performance of verbal and perceptual-motor skills and ensure maximum payoff from the training time invested.

## Approach

An extensive literature survey was conducted to identify training procedures that promote task learning, retention, and transfer. The survey was accomplished using prior reviews of the behavioral, information processing, cognitive, educational, and military training literature, as well as original research reports found in major documentation sources such as the Defense Technical Information Center, National Technical Information Service, Educational Resources Information Center, and Psychological Abstracts. Summarized herein are the results of this survey.

## Definitions

### Learning

Learning is defined as a relatively permanent change in performance as a result of practice. As shown in Figure 1, the course of learning is predictable. Performance improves rapidly at first and can be readily observed and measured. As training continues, performance also continues to

improve but at a slower rate, until finally, little measurable improvement is observed as proficiency is approached toward the end of training.

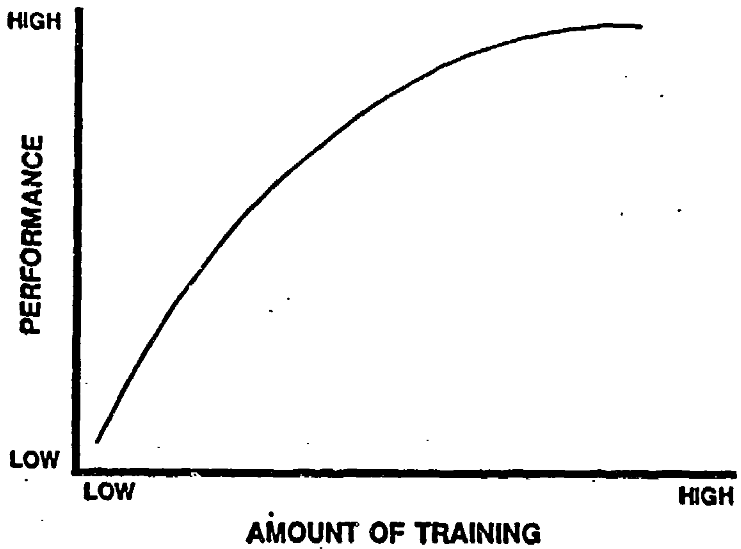


Figure 1. The typical course of learning.

## Retention

Retention refers to the maintenance or sustainment of learned information over intervals of no practice. The general course of retention is also predictable. As shown in Figure 2, performance decreases rapidly soon after training and continues to drop, but at a slower rate, as the no-practice interval increases. Theoretically, forgetting (i.e., the flip side of retention) can be complete. Practically, however, once a task is learned at least some aspects of it are retained even after prolonged intervals of no practice.

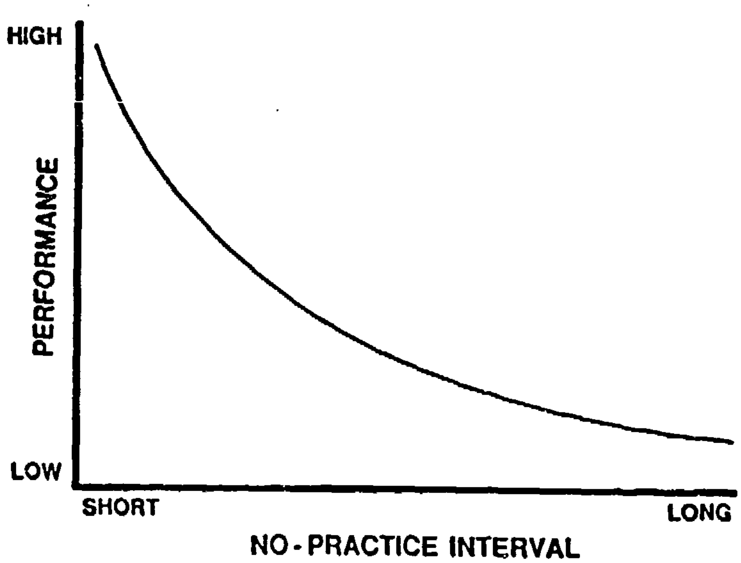


Figure 2. The typical course of retention.

## Transfer

Transfer refers to the effect of learning one task on the subsequent learning or performance of another. Transfer can be positive, negative, or neutral (zero), and is defined operationally on the basis of manipulations such as those shown in Figure 3 where Group E learns both Task 1 and Task 2, and Group C learns only Task 2. If the performance of Group E on Task 2 is better than the performance of Group C, then transfer is positive. If Group C outperforms Group E on Task 2, then transfer is negative. And lastly, if the performance of Groups E and C fails to differ, then transfer is zero.

| | Learning | |
|---|---|---|
| | Task 1 | Task 2 |
| Group E | Yes | Yes |
| Group C | No | Yes |

Figure 3. Basic procedure for defining transfer.

From these brief definitions, it is apparent that learning, retention, and transfer are interrelated processes (Houston, 1976). Information learned during Task 1 training, for example, will transfer to the performance of Task 2 only if this information is retained during the no-practice interval that often occurs between performance of the two tasks. Furthermore, the amount of retention and transfer obtained depends to a large extent upon the degree to which a task is learned initially.

Given this interrelationship among the three processes, training procedures found to have an effect on one process, e.g., learning, can be expected to have an effect on the others, e.g., retention and transfer. In the discussion of training procedures that follows, an attempt is made to address the effect of each procedure on learning, retention, and transfer (where known) before moving on to discussion of the next procedure.

# Pretraining Procedures

As the name implies, these procedures or strategies are applied before training begins. Four general types of pretraining procedures have been investigated in the literature: Use of pretests, behavioral objectives, overviews, and advance organizers. The first three have been examined primarily for their effects on learning, whereas advance organizers have also been examined for their effects on retention and transfer.

## Pretests

A pretest is any set of questions related to the information or skill to be learned. Pretests are administered before training to determine how much task-related information trainees already know. In addition, pretest scores can be compared with posttest (i.e., a test administered after training) scores to evaluate training program effectiveness.

Effects of pretests have been examined in a variety of contexts to include industrial training (Warr, Bird, & Rackham, 1970), film research (Lumsdaine, 1963), attitude and opinion change (Welch & Walberg, 1970), text learning (Frase, 1970; Rothkopf, 1970), and symbol learning (Hartley, 1973). Results indicate that pretests can be used to improve learning as well as to evaluative it.

Warr, Bird, and Rackham (1970), for example, conducted an experiment with 43 foremen studying accident prevention. The foremen were divided into three groups. Group 1 took half of the posttest as a pretest before training. Group 2 took the other half of the posttest as a pretest. Group 3 was not pretested. Overall, the two pretested groups performed better than the nonpretested group on the posttest. Posttest performance was (a) best on pretested questions, (b) next best on nonpretested questions, and (c) worst when no pretesting was conducted at all.

According to Hartley and Davies (1976), pretests enhance learning when they alert trainees to what it is they must know after training has been completed. Thus, pretests provide the RC trainer with an easy-to-use mechanism for highlighting task importance and enhance learning when they focus trainees on issues or concepts that may otherwise go unnoticed during training.

## Behavioral Objectives

Behavioral objectives (a) identify behavior that will be accepted as evidence that learning has occurred, (b) define conditions under which this behavior must occur, and (c) specify the standard for determining if performance is acceptable (Mager, 1962). Although their focus is similar to that of pretests, behavioral objectives are somewhat different because they are usually designed for the express purpose of improving learning. Gagne (1965) states that behavioral objectives promote learning by (a) providing trainees with a clear goal that can be used to organize learning activities, (b) permitting more efficient study, (c) reducing time spent on irrelevant information, and (d) providing a benchmark against which trainees can objectively judge their own progress.

The degree to which behavioral objectives influence learning is generally a function of three factors: training method, type of task, and trainee characteristics.

Training Method. Behavioral objectives work best when used by trainees as directions to learn specific subsets of materials (Kaplan, 1975), and therefore, should be provided by the RC trainer at the beginning of training to promote maximum effectiveness (Aagard & Braby, 1976). In addition, disclosing objectives prior to traditional lecture-based training is more effective than doing so prior to more nontraditional programed or computer-based training (Sink, 1973). The highly structured nature of computer-based training reduces the need for objectives, whereas the less structured nature of lecture-based training leaves more room to benefit from the organization provided by behavioral objectives.

Type of Task. Behavioral objectives work better with some types of tasks than with others. After reviewing past research, Hartley and Davies (1976)

conclude that behavioral objectives do not improve the learning of tasks calling for knowledge and comprehension whereas they do benefit the learning of higher order tasks calling for analysis, synthesis, and evaluation.

Trainee Characteristics. Although not much research has been done in this area, it can be tentatively concluded that behavioral objectives work best with (a) male trainees from higher socioeconomic backgrounds (Etter, 1970), (b) trainees with at least average ability level (Cook, 1969), and (c) trainees who are not conscientious in their work habits (Kueter, 1971).

## Overviews

Another common pretraining strategy involves the use of overviews or summaries. Generally speaking, overviews present key concepts, principles, and technical terms, as well as provide a preview of the general structure of the material to be learned. Although overviews can take pictorial, graphic, and typographic form (see Hartley, Fraser, & Burnhill, 1974, for a bibliography of typograhic research relevant to the production of training materials, and Burnhill & Hartley, 1975, for a critique of this research), they typically take the form of text.

Most of the research on overviews has used written or spoken text to preface information presented in films. In this context, learning has been enhanced (May & Lumsdaine, 1958; Northrop, 1952).

Although most researchers agree that overviews promote learning, others note that the additional training time required to present an overview can sometimes be used just as effectively in other ways (this can probably be said of all forms of pretraining procedures). Weiss and Fine (1956), for example, found that the benefit of presenting an overview prior to showing a film could also be obtained by showing the film twice, and that repetition of the film consumed no more time than that required to present the overview.

## Advance Organizers

Advance organizers are more complex than overviews and serve a different function than either pretests or behavioral objectives. Unlike a set of questions or a list of objectives that are meant to alert or prepare trainees, advance organizers are meant to provide a broad conceptual framework that trainees can use to clarify the task ahead (Ausubel, 1969). Advance organizers emphasize context, whereas pretests, objectives, and overviews emphasize content (Hartley & Davies, 1976).

Two basic types of advance organizers exist: expository and comparative. Expository organizers are used when the material to be learned is totally unfamiliar. In these cases, the organizer helps trainees to relate new information to knowledge they already possess. Comparative organizers are used when the new information is not completely novel. These organizers serve to specify precisely how the new material is distinct from what trainees already know, thus helping to ensure that the new information is not confused or inappropriately merged with the old (Hartley & Davies, 1976). Trainees, for instance, reading material on Buddhism tend, within a relatively short time, to merge this knowledge into their already existing concepts from our

Judeo-Christian tradition (Ausubel, 1963). Comparative organizers help prevent this dilution or interference from occurring.

The most common form of advance organizer is the continuous text or prose passage, although other formats, such as maps and other kinds of graphics have also been used (e.g., Weisberg, 1970). Mayer (1978), for example, in training basic computer programming skills, used an advance organizer consisting of a 500-word passage describing the functions of a computer using metaphors of familiar objects, e.g., a ticket window, scoreboard, notepad, and so forth, to facilitate learning.

Results of most research to date suggest that advance organizers facilitate learning (Kloster & Winne, 1989), retention (e.g., Ausubel, 1960), and transfer (Mayer, 1979). Like overviews, their benefits are similar to those found with repetition of the material to be learned (Mayer, 1983). In general, advance organizers are most effective in situations where the information to be learned (a) requires a conceptual framework to enhance understanding, (b) possesses a dominant structure that can be readily integrated with existing knowledge, or (c) where stress or inexperience reduce the likelihood that trainees will be able to supply their own appropriate organizational structure during training (Mayer, 1979).

Mayer (1979) suggests that the effects of advance organizers on transfer can be accounted for by two processes: conceptual anchoring, i.e., integration of key ideas from the text with the trainee's existing knowledge base, and obliterative subsumption, i.e., loss of minor details and technical facts when new knowledge is integrated with old knowledge. As a result, advance organizers often facilitate the learning of conceptual ideas more than technical details, and thus, can be used most effectively to facilitate transfer of general concepts from one situation to another (Grotelueschen & Sjogren, 1968; Merrill & Stolurow, 1966; and Scandura & Wells, 1967).

In summary, use of pretests, behavioral objectives, overviews, and advance organizers prior to the start of training can enhance the learning that occurs thereafter. Pretests alert, behavioral objectives inform, overviews prepare, and advance organizers clarify. They give direction to learning through their introductory or anticipatory role, and provide an overall learning set for what is to follow. If used by the RC trainer, pretraining procedures should enhance soldier performance as well as guide the training planning process, thereby reducing RC soldiers' perceived need for improved organization of IDT (Eisley & Viner, in preparation).

## Repetition

Regardless of whether pretraining procedures are used or not, once training begins, repetition is necessary to ensure proficiency on all but the simplest of tasks. Repetition improves the performance of both verbal (e.g., Hellyer, 1962; Melton, 1963; Postman, 1962) and perceptual-motor tasks (e.g., Adams & Dykstra, 1966), as demonstrated by greater accuracy, increased speed of responding, or both.

Repetition is a primary determinant of learning, retention, and transfer (e.g., Farr, 1986; Gardlin & Sitterley, 1972; Hurlock & Montague, 1982), as shown in numerous experiments conducted by the U.S. Army Research Institute

over the last decade (e.g., Goldberg, Drillings, & Dressel, 1981; Hagman, 1980a; Schendel & Hagman, 1982). Hagman (1980a), for example, found that repeating a 52-step procedural task, required to test alternator electrical output, from one to four times during training reduced task performance time and errors during learning and at a retention test conducted two weeks later.

Repetition is also effective after task proficiency has been achieved (Underwood, 1964). Repeating a task beyond the point at which it is judged to be learned (e.g., one correct performance) increases retention, as shown for a variety of tasks including M60 Machine Gun disassembly/assembly (Schendel & Hagman, 1982), testing of alternator electrical output (Hagman, 1980a), and tank gunnery skills (Goldberg, Drillings, & Dressel, 1981), to mention just a few. Thus, extra repetitions during initial training will promote learning, increase retention, and reduce the need for frequent refresher training (Schendel, Shields, & Katz, 1978).

An illustration of the beneficial effect of repetition on retention is shown in Figure 4. The dotted line shows a hypothetical point of minimum task proficiency. Once performance falls below this point, a need for refresher training would be indicated. Trainees in the high-repetition training condition will take longer to decline to this point, and thus, will require less frequent refresher training than trainees in the low-repetition training condition (Loftus, 1985). Furthermore, high-repetition trainees will outperform low-repetition trainees over the entire duration of the no-practice interval.

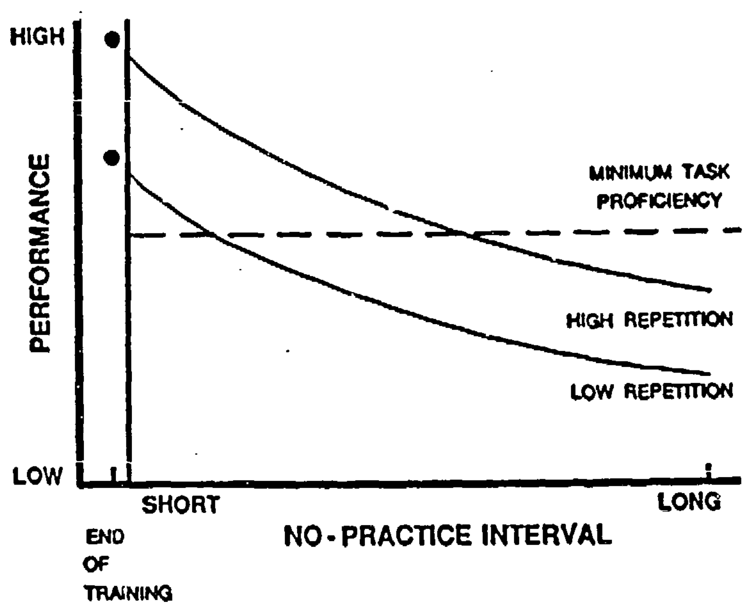


Figure 4. Learning and retention for low- and high-repetition training groups.

With increased repetition also comes relatively systematic effects on transfer, as summarized by Mandler (1962). That is, with small amounts of repetition (and therefore learning) transfer is typically negative, returns to zero with more repetition, and finally becomes positive with further repetition. Thus, positive transfer from Task 1 to Task 2 becomes more probable with increased practice on Task 1 (e.g., Hagman & Schendel, 1981).

Unfortunately, it is difficult to determine exactly how much training is necessary for achieving maximum transfer. Furthermore, there is a danger that too much training can result in response automatization which decreases the probability of successful transfer. Automatization occurs when the same task is repeated over and over such that trainees can perform it with less and less attentional capacity (Cormier, 1987; Schneider & Fisk, 1982). Extended training can make a response so tied to the specific task characteristics or stimuli that even a slight change in task requirements can create deficits in transfer (Eberts & Schneider, 1985; Luchins, 1942; Salthouse & Somberg, 1982; Shiffrin & Schneider, 1977) and result in responses that cannot be easily modified through retraining (Cormier, 1987).

In an often cited example of the adverse effects of repetition on transfer, Luchins (1942) asked trainees to solve a series of "water jar" problems involving three jars of varying sizes and an unlimited water supply. Trainees were asked to figure out how to obtain a required amount of water. For example, given jars containing 21, 127, and 3 units of water, obtain 100 units of water. The first six problems all could be solved by an indirect method (e.g., Jar B - Jar A - 2 Jar C), whereas a seventh problem could be solved by a simpler direct method (e.g., Jar A -Jar C). As a result of solving six problems in a row via the indirect method, trainees were unable to identify that the easier direct method was more appropriate for solving the seventh problem. Thus, too much repetition in use of the indirect approach produced rigidity in problem solving and inhibited transfer to a problem in which a different, more efficient, solution approach was possible.

In summary, repetition is a key factor promoting learning, retention, and transfer and should be emphasized by the RC trainer during training. How much repetition to use will depend on the goal of training. If, on the one hand, the goal is to promote learning and retention of a specific task, then the more repetitions the better. If, on the other hand, the goal of training is also to promote transfer to other tasks, then fewer specific task repetitions are recommended along with an increase in the variety of tasks trained (see later section on task variety). Exactly how many repetitions are required for achieving each goal is unknown and awaits further research. It seems relatively safe to say, however, that within the time-constrained RC training environment, the probability is low that most institutional or field training programs would ever reach the point where the number of task repetitions performed would adversely affect transfer.

## Repetition Schedule

While repetition is the key to attaining and maintaining task proficiency, it also takes time: an RC resource that is in short supply. Repeating a task only until minimum proficiency (i.e., one correct performance) is achieved will take less initial training time than providing additional repetitions (i.e., overtraining) but will also result in greater refresher training time being needed later on. By spacing repetitions, however, the RC trainer can reduce the need for frequent refresher training without increasing the time spent on initial training.

### Verbal Tasks

For verbal tasks, results of extensive laboratory and field research

indicate that learning (or at least performance) is better when the interval between task repetitions is minimized, i.e., massed training. In contrast, retention is better when the interval between repetitions is increased, i.e., spaced training (e.g., Crowder, 1976; Glover & Corkill, 1987; Greene, 1989; Rose, McLaughlin, Felker, & Hagman, 1981).

In general, the retention benefits of spaced training for verbal tasks increase as the interval between repetitions increases (Crowder, 1976), provided that it is not too long (Glenberg, 1974; Young, 1966). Thus, benefits from spacing follow an inverted U function similar to that shown in Figure 5. Presumably, when the interrepetition interval is too long, excessive forgetting occurs between repetitions and learning suffers (Atkinson & Shiffrin, 1968). Unfortunately, the literature does not tell us how long of an interrepetition interval is too long. Results of three list-learning experiments conducted by Glenberg and Lehman (1980), however, suggest that spacing benefits can be found with interrepetition intervals of up to two weeks in some cases with verbal materials.

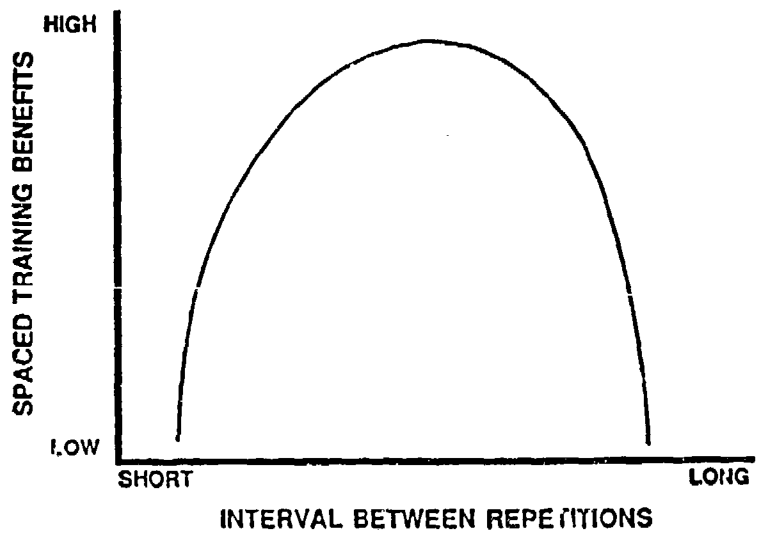


Figure 5. Course of spacing benefits hypothesized to occur over increased interrepetition intervals.

Two explanations have been offered to account for the retention benefits accompanying spaced training. Briefly, one suggests that spacing improves recall because to-be-remembered information is stored with a greater variety of retrieval cues (e.g., Crowder, 1976). When a word, for example, is repeated twice in succession (i.e., massed training), each mental representation of the word will have a very similar set of accompanying associations or cues (e.g., adjacent words, casual thoughts, etc.) to aid later retrieval from memory. But if the repetitions are spaced, each representation will have a set of potentially different retrieval cues. The greater the number and variety of these accompanying cues, the greater the benefit on memory will be.

The other explanation involves the notion of attention. It suggests that trainees tend to be easily bored with successive repetitions of the same material. So when they receive two presentations of a word, one after

another, they will not give as much attention or mental effort to the second presentation. To illustrate this point, Johnston and Uhl (1976) had two groups of college students perform two tasks at the same time. The first task was to listen to several lists of about 100 words presented over headphones to the right ear at a rate of one every five seconds. Some of the words were repeated four times in the list, either in succession (massed repetitions), or at four separate times during the list (spaced repetitions). The second task was to press a button as quickly as possible whenever a faint tone was heard over the headphones in the left ear.

As predicted, students retained more words after spaced than after massed presentations. In addition, as shown in Figure 6, their reaction times to the tones decreased across successive repetitions when they were massed, whereas the times increased with repetitions when they were spaced. Presumably, under massed repetitions students paid less attention to the successive word presentations and had more attention to devote to detection of the tone, whereas the opposite occurred when word repetitions were spaced.

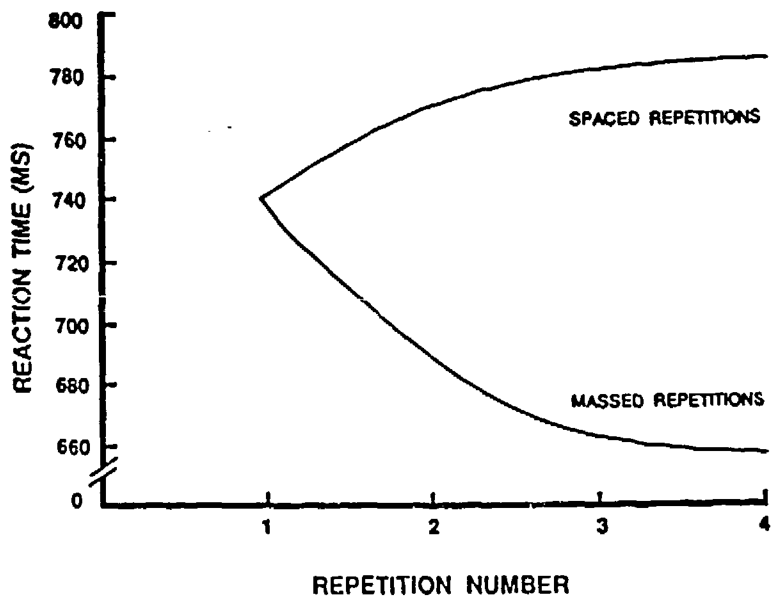


Figure 6. Time to detect tone presentations during word repetitions. From "The Contributions of Encoding Effort and Variability to the Spacing Effect on Free Recall" by W. A. Johnston and C. N. Uhl, 1976, Journal of Experimental Psychology: Human Learning and Memory, 2, p. 156. Copyright 1976 by the American Psychological Association, Inc. Adapted by permission.

## Perceptual-Motor Tasks

For perceptual-motor tasks, learning and retention appear to be comparable under massed and spaced repetition schedules (Holding, 1965; Schmidt, 1975). This holds true for both discrete perceptual-motor tasks, i.e., tasks that have a definite beginning and end and are typically less than 5 seconds in duration, such as throwing a hand grenade or moving a gear-shift lever, as well as continuous perceptual-motor tasks, i.e., movement patterns that have no particular beginning or end. Pursuit and compensatory tracking are examples of continuous tasks in which trainees attempt either to (a) keep

a cursor aligned with a target, e.g., keeping a weapon sight (cursor) on a moving tank (target), or (b) nullify the difference between an error indicator and a fixed reference, e.g., making navigational corrections based on the difference between the intended and actual course, or leveling a bridge based on the degree of tilt indicated by the position of a floating bubble in a glass tube.

Although performance of continuous tasks appears to be better under spaced scheduling (Ammons, 1951), massing of repetitions often leads to boredom and fatigue that mask the amount of learning that actually takes place (e.g., Lewis & Lowe, 1956). Giving trainees rest after massed training typically results in continuous task learning levels comparable to those achieved under spaced schedules (e.g., Adams & Reynolds, 1954).

There are some situations, however, when spaced repetitions are definitely recommended for training perceptual-motor tasks. These include the training of (a) dangerous tasks where fatigue from continuous practice could put trainees at risk (Schendel, et al., 1978), (b) poorly motivated soldiers who are adversely affected by the rigorous nature of massed scheduling (Kleinman, 1980), and (c) high ability soldiers who tend to make more responses during massed scheduling, quickly become fatigued, and accordingly respond at a lower level of proficiency than soldiers of lower ability (Eysenck & Frith, 1977). Spaced schedules also appear to be more effective for mental practice (Corbin, 1972).

Lastly, the RC trainer should note that adoption of a spaced repetition schedule does not necessarily mean that more time will be required for training to accommodate rest periods. Rather than resting between repetitions, it is recommended that training repetitions of one task be inserted between training repetitions of another. Such a task alternation procedure not only ensures efficient use of valuable training time but also is a way to simulate longer interrepetition intervals and produce enhanced retention (Bjork & Allen, 1970).

## Mental Practice

Repetition does not necessarily need to be overt, or "hands-on," to enhance performance. This is fairly obvious for verbal tasks which fundamentally require mental manipulations that can easily be rehearsed covertly, e.g., mentally repeating a telephone number before dialing. It is not so obvious for perceptual-motor tasks where, by definition, physical movements are required for demonstration of successful learning, retention, or transfer.

There is no doubt that overt physical repetition is necessary for learning most perceptual-motor tasks (Schmidt, 1982). Some evidence suggests, however, that perceptual-motor tasks can be enhanced as much, or even more, by the combination of mental and physical practice (Richardson, 1967a; 1967b). Mental practice of perceptual-motor tasks involves imagining the performance of a movement without any overt action. This presumably allows trainees to think about the kinds of movements to make, as well as their consequences, thereby eliminating incorrect actions and speeding up learning. These learning benefits are not restricted to a particular type of task. When combined with physical practice, for example, mental practice has been found

to enhance the learning of a wide variety of tasks such as bowling (Waterland, 1956), ball throwing (Stebbins, 1967), tracking (Rawlings, Rawlings, Chen, & Yilk, 1972), and procedural or step-following tasks (Richardson, 1967b), to mention just a few.

Rawlings, et al. (1972), for example, examined the effect of mental practice on a rotary-pursuit tracking task in which the training goal was to keep a hand-held pointer on top of a moving cursor as it traveled around in a predefined circle. Three groups of trainees received 25 trials on the task on Day 1, and then differed in their practice method over the next nine days. A physical-practice group practiced 25 trials per day, a no-practice group received no practice, and a mental-practice group practiced only by imagining and visualizing the task. On Day 10, all trainees were tested on the task for 25 trials. As shown in Figure 7, the mental-practice group performed almost as well as the physical-practice group on Day 10, whereas the no-practice group showed little improvement.

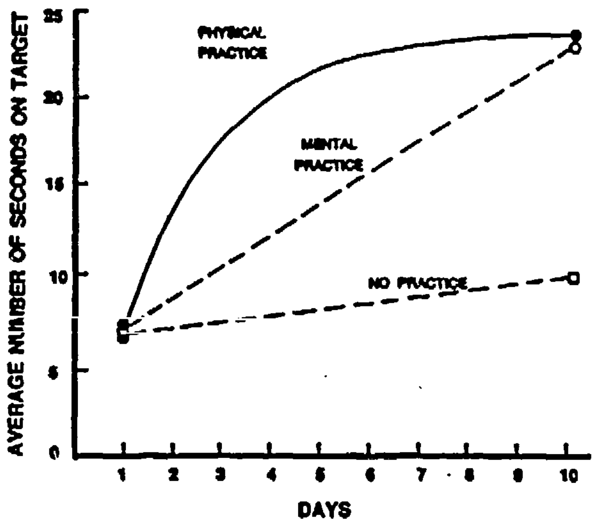


Figure 7. Relative performance effects of physical and mental practice on rotary-pursuit performance. From "The Facilitating Effects of Mental Rehearsal in the Acquisition of Rotary Pursuit Tracking" by E. I. Rawlings, I. L. Rawlings, S. S. Chen, and M. D. Yilk, 1972, Psychonomic Science, 26, p. 72. Copyright 1972 by the Psychonomic Society, Inc. Adapted by permission.

Although findings on mental practice effects are still relatively limited, available evidence suggests that: (a) a combination of physical and mental practice is probably better than mental practice alone (Singer, 1975), (b) mental practice is effective both during the initial stages of training when verbal-cognitive processes are most involved (Adams, 1971; Fitts & Posner, 1967; James, 1890; Schmidt, 1982; Singer & Witker, 1970), and late in training when movements have been learned and trainees are more likely to be able to conceptualize them mentally (Clark, 1960; Singer, 1975), and (c) mental practice sessions should not exceed 5 minutes in length if effective concentration is to be maintained (Gilmore & Stolurow, 1951; Twining, 1949).

Thus, mental practice could be an effective and efficient procedure for RC trainers to use in filling the relatively short (and sometimes

unanticipated) periods of "down time" that often occur during training sessions, e.g., when groups of soldiers cannot all be trained at once, or when training is interrupted because of equipment breakdown. Use of mental practice could turn this down time into productive training time without any additional investment of training resources.

## Intention to Learn

The benefits of repetition can be maximized if trainees also intend to learn the task. Although nonintentional or incidental learning is certainly possible (e.g, Farr, 1986), intention to learn energizes and directs attention (Miller, Galanter, & Pribram, 1960) and appears to elicit a level of "cognitive effort" (Tyler, Hertel, McCallum & Ellis, 1979) needed for moving information from temporary storage (i.e., short-term memory) to permanent storage (i.e., long-term memory). Once in permanent storage, information is said to be learned and capable of being retained over prolonged intervals of no practice (Nuttin & Greenwald, 1968).

Learning and retention are maximized when trainees have an intention to learn before training begins rather than afterward, especially if no opportunity for subsequent training is provided. The RC trainer can help supply this intent by assisting trainees in setting effective performance goals (LaPorte & Nath, 1976) and by indicating the future utility of to-be-learned information (Travers, 1972). LaPorte and Nath (1976), for example, tested two groups of college students on their retention of two, 30-sentence text passages on the neural functioning of the brain and the history of lumber and mining towns. Students who were given a difficult performance goal (i.e., correctly answer 18 out of 20 test questions) answered more test questions correctly than students who were given an easy performance goal (i.e., correctly answer 5 out of 20 test questions).

## Knowledge of Results (KR)

Repetition and intention to learn are two important factors recommended for achieving effective learning, retention, and transfer. A third, and perhaps most important, factor is KR (often called "feedback" by the military). KR is defined as a verbal or mechanical indication of the outcome of a response. Thus, KR provides trainees with information (knowledge) about the adequacy (results) of their responses. This information can be provided by the RC trainer in the form of error discrepancy between an obtained response and some externally defined criterion, or in the form of the actual outcome of the response. During training, KR is normally provided by either the trainer (e.g., saying "right" or "wrong"), or by the external environment (e.g., the time score from a clock, or the return of a repair part requisition).

Irion (1966) states that KR is the most important factor determining learning while Schendel, et al. (1978) also emphasize the importance of KR, especially during the early stages of training. Others agree that repetition or practice must be followed by KR to ensure increased response accuracy with respect to an external criterion (Annett, 1959; Gick & Holyoak, 1987; Thorndike, 1927). The use of KR provides reinforcement when a response is correct, and furnishes corrective information when an error is made.

The effects of KR on learning are influenced by several factors. These include the (a) length of time passing between a response and receipt of KR, i.e., KR-delay, (b) amount of time passing between KR and the next response, i.e., post-KR delay (see Figure 8 for the relationship between KR-Delay and post-KR-Delay intervals), (c) precision of KR, (d) frequency of KR, and (e) when KR is withdrawn during training.

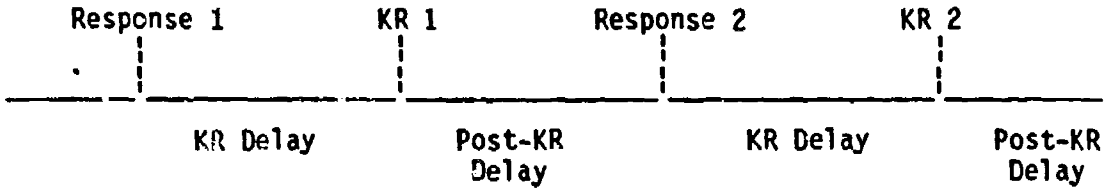


Figure 8. The relationship between KR-Delay and Post-KR-Delay intervals.

## KR Delay

Slower learning occurs only when KR is delayed beyond performance of the next trial or response (Becker, Mussina, & Persons, 1963; Lavery, 1964; Lorge & Thorndike, 1935; Shea & Upton, 1976). As long as performance of the next response does not interfere with mental processing of what was done on the previous response, delay of KR will not adversely affect task learning (Kerr, 1973).

Although delaying KR tends to slow down learning, increasing the KR-delay interval can actually enhance retention. At least 11 experiments have reported superior retention with KR delays of 24 and 48 hrs (e.g., Kulhavy & Anderson, 1972; Kulhavy, Yekovich, & Dyer, 1979; Surber & Anderson, 1975). In addition, Sturges (1978) showed similar benefits of KR delay for computer-assisted training - an area where training is based primarily on the principle that immediate KR is crucial for learning to occur.

## Post-KR Delay

Trainees need adequate time to process the information contained in KR and make plans for the next response (Adams, 1987; Bilodeau, 1966). The amount of time needed varies directly with the complexity of KR (e.g., the more or precise information it contains). Rogers (1974), for example, varied the length of the post-KR delay interval as well as the precision of KR, ranging from qualitative KR such as "too far" to quantitative KR that varied in precision, like 3, 3.2, or 3.214. He found that performance of a micrometer positioning task degraded as the complexity of KR increased, but not when the post-KR interval was long enough for the trainee to process the information. Thus, with complex or very precise KR, the RC trainer should insert a longer post-KR delay interval during training to ensure that trainees have fully processed the information before going on to the next response.

## Type of KR

It is more effective for learning to (a) tell trainees that they are wrong when their response is incorrect than it is to tell them that they are right when their response is correct (Buss, Braden, Orgel, & Buss, 1956), and (b) provide the correct response rather than simply indicating that a response

is wrong (Anderson & Faust, 1973). Furthermore, quantitative KR, such as how much the response was off, is more effective than qualitative KR, such as "right" or "wrong" (Trowbridge & Cason, 1932).

At the same time, the RC trainer must be conscious of making KR too quantitative, because excessive precision can actually retard learning (Ammons, 1956; Newell & Kennedy, 1978; Rogers, 1974). Unfortunately, past research does not reveal how precise KR should be for specific tasks. Newell (1976), however, suggests that trainee ability to process complex KR varies with age as well as the difficulty of the task. Younger trainees are less apt to be able to process complex KR (Farnham-Diggory, 1972; Wickens, 1974), and the more difficult the training task, the less likely it will be that trainees will have sufficient processing capacity available to take full advantage of highly precise KR, especially if the post-KR delay is short (see above). Thus, the RC trainer should not give highly precise KR during the training of difficult tasks until a moderate level of learning has been reached. Thereafter, task performance will require less attentional capacity and trainees will have more capacity left over for processing the KR provided.

In his recent review of motor skill research, Adams (1987) suggests that more complex KR, in the form of both segment and overall correctness information, should be provided during the learning of difficult movement sequences. If a movement is viewed as a sequence of coordinated muscular responses, then certain segments may be more influential than others in facilitating successful performance. In a golf swing, for example, the arc and speed of swing may be more important for successfully driving the golf ball than the position of the club at the start of the motion. If KR is provided only in terms of the general outcome of the swing (e.g., the ball hooked to the left or sliced to the right), a trainee must infer or try to guess which motor segments are the most significant for successful performance of the entire sequence and then attempt to make the necessary modifications on the next response (swing). For movement sequences such as these, providing both segment and outcome KR will result in better learning than providing outcome KR alone (Adams, 1985).

## Frequency of KR

Amount of KR can be measured in terms of absolute and relative frequency. Absolute frequency is simply the number of KR presentations provided during the course of training. Relative frequency refers to the percentage of responses on which KR is provided. The latter is computed by dividing the number of KRs provided by the total number of responses, and multiplying by 100 to convert the result to a percentage. Thus, a 50% relative frequency means that KR is given on half of the responses performed during training.

In general, absolute frequency of KR is more important for improving learning (Johnson, Wicks, & Ben-Sira, 1980, as described in Schmidt, 1982), whereas the relative frequency of KR is more important for ensuring effective retention and transfer (Ho & Shea, 1978; Schmidt, Shapiro, Winstein, Young, & Swinnen, 1987; Schmidt, Young, Swinnen, & Shapiro, 1989). For example, Schmidt, et al. (1987) in a series of experiments trained college students to perform different kinds of movements under various relative frequency combinations of KR. In general, decreases in the relative frequency of KR had little effect on acquisition performance but improved movement retention as

well as transfer to a no-KR condition. These researchers also used an effective procedure, called "fading," whereby the relative frequency of KR starts out relatively high (e.g., 50% of the trials) early in training and then is gradually reduced as training continues. Fading was found to produce superior long-term retention as compared to a 100% relative frequency of KR condition. Fading presumably reduces the dependency of trainees on external KR and promotes their reliance on cues intrinsically present in the task itself.

Thus, whether an RC trainer should use absolute or relative KR during training depends on how long the retention interval is between the end of training and start of the job. If this delay is minimal (on the order of hours or possibly days) then providing KR after every response is the recommended procedure. If the delay is significant (weeks or months) then including some no-KR trials in among KR trials appears to be the more effective procedure. Unfortunately, an exact, across-the-board number or percentage of KR trials cannot be specified for every training situation because the exact number of learning trials required to achieve response proficiency depends on the task itself and the experience level of the trainee.

## KR Withdrawal

The effect of withdrawing KR during training varies inversely with the number of previous task repetitions provided during training. On the one hand, if KR is withdrawn early in training (e.g., before a task is learned to a reasonable level of proficiency), then a decrement in learning will result (Schmidt, et al. 1987). On the other hand, if KR is withdrawn later in training (when a reasonable level of proficiency has been demonstrated), then the effect will not be as detrimental (Adams, Goetz, & Marshall, 1972; Newell, 1974; Roy & Marteniuk, 1974; Schmidt & White, 1972).

# Response-Produced Feedback

Response-produced feedback refers to the inherent sensations (e.g., proprioceptive, kinesthetic, visual, auditory cues) received as a consequence of making a perceptual-motor response (Adams, 1968). Although the theoretical status of response-produced feedback is still controversial (e.g., Adams, 1976), few doubt its practical importance for the learning and retention of perceptual-motor skills.

Adams (1971) theorizes that response-produced feedback is used by trainees in conjunction with KR to help remember how a correctly performed movement feels, looks, and sounds. This memory starts out weak, and thus, trainees tend to rely heavily on KR for information about movement correctness early in training (Newell, 1974). As learning progresses, however, after a stronger representation of the correct movement has been stored in memory, trainees can detect their own movement errors by comparing the response-produced feedback qualities of the movement just made with that of the correct movement to be remembered. Thus, they no longer have to rely on KR for information about correctness, especially later on in training. If this argument is correct, it would explain why the need for KR becomes less and less as training progresses (e.g., Adams, 1971) and the finding that KR can be

withdrawn late in learning without resulting in major performance decrements (e.g., Schmidt, 1982).

Findings on the importance of response-produced feedback for learning have been consistent. In general, the more response-produced feedback provided, the more accurate and confident trainees' responses will be (Schendel et al., 1978; Schmidt & Wrisberg, 1971; Stelmach, 1973). In addition, retention is facilitated by increasing the number of feedback channels during training, as shown for a wide variety tasks and retention intervals (e.g., Mengelkock, Adams, & Gainer, 1971; Stelmach & Kelso, 1975), with the most important feedback channel being vision (Adams, Goetz, & Marshall, 1972; Adams, Gopher, & Lintern, 1977; Henderson, 1977). Thus, the RC trainer should structure training so as to provide as many response-produced feedback channels as possible, especially vision, in order to ensure effective learning and retention.

## Augmented Feedback

Besides response-produced feedback intrinsic to the task to be learned, it is possible to provide augmented feedback during training in the form of extra cues or information that would normally not accompany the task being performed. In attempting to learn the correct sight picture in tank gunnery, for example, the sight picture itself would be visual feedback intrinsic to the task. If a buzzer sounded when the correct sight picture were attained, then the buzzer would be considered augmented feedback.

The presence of augmented feedback during training typically facilitates performance and speeds up training (e.g., Briggs, 1969). Unfortunately, these beneficial effects are transitory and usually do not transfer to situations where augmented feedback is not present. As shown in Figure 9, when augmented feedback is removed, trainees show no benefit from having been trained with augmented cues. Bilodeau (1952), for example, has shown this to be the case for a target gunnery task. Under the normal sighting procedure, gunners were required to adjust their controls so as to frame or superimpose a number of dots upon a moving target airplane. Gunners in Group A received normal feedback in the form of visual error i.e., the spatial difference between the dots and the target. Those in Group B received normal feedback plus augmented feedback in the form of a target color change from white to red when a response shifted from incorrect to correct. Although trainees in Group B performed better than trainees in Group A when augmented feedback (i.e., target reddening) was present, they failed to show superior performance when the augmented feedback was removed.

Researchers argue that lack of positive transfer from augmented to nonaugmented feedback conditions is the result of trainees becoming dependent upon augmented cues during initial training. When these cues are removed, performance declines because the intrinsic task cues normally present to guide performance have not been attended to. Thus, augmented cues are used as a "crutch," and when the crutch is removed performance suffers (e.g., Boldovici, 1987).

In many situations, this dependency or "crutch effect" can be minimized or even eliminated altogether by the RC trainer through use of a procedure called adaptive withdrawal (Lintern & Roscoe, 1980), wherein augmented

feedback is provided only when a trainee's response exceeds a specific error limit or deviates significantly off course. As training continues and responses improve, augmented feedback is withdrawn because the number of error-free responses gradually increases (Lintern, 1980).

Adaptive withdrawal, therefore, is a procedure that (a) takes advantage of the rapid training effects of augmented feedback, (b) promotes transfer by eliminating augmented feedback dependencies, and (c) encourages use and discrimination of intrinsic task cues necessary for successful performance when augmented cues are withdrawn. Because of these benefits, an adaptive withdrawal procedure should be considered a prime candidate for use in RC training programs, especially those conducted with simulators and computer-based training devices where the precise presentation and withdrawal of augmented feedback can be easily controlled.

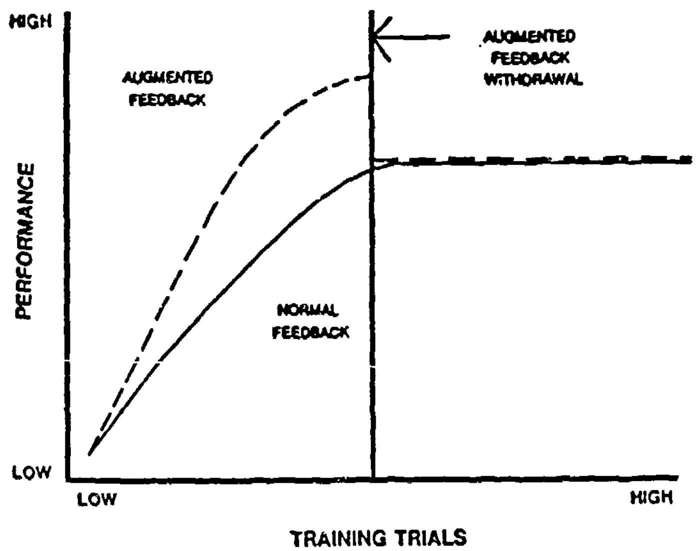


Figure 9. Effect of withdrawing augmented feedback during training.

## Guidance vs Discovery

Guidance (sometimes referred to as prompting) and discovery training procedures have been examined particularly in relation to their effects on learning and transfer. According to Schmidt (1982), guidance can refer to a variety of procedures, ranging from physically pushing and pulling the trainee through a movement sequence, to preventing incorrect responses by physical limitations on an apparatus, or even verbally "talking the trainee through" a new task. Thus, under a guidance procedure trainees are literally told or shown what to do, whereas under a discovery procedure they must determine on their own what to do or not to do, usually through the process of trial and error.

Research examining which of the two procedures is most effective has revealed relatively consistent findings for both verbal and perceptual-motor tasks. If the purpose of training is to learn a particular task and only that task, a guidance procedure will produce more accurate and quicker learning, and therefore, is recommended (Aiken & Lau, 1967; Guthrie, 1967; Holding & MacRae, 1966; MacRae & Holding, 1965, Singer & Pease, 1976). Guidance should

also be used when safety is a concern (Schmidt, 1982) and when trainees are incapable of identifying a correct response or performing a correct movement on their own. Furthermore, a guidance procedure that allows trainees to experience alternative responses will be more effective than one that always results in the correct response or movement (Annett, 1959). This will better enable trainees to make the required critical discrimination between correct and incorrect (Holding, 1965).

If the purpose of training is to apply what has been learned to another task or situation, i.e., transfer, then training should stress discovery (e.g, Aiken & Lau, 1967; Singer, 1977; Singer & Pease, 1976). This is true as long as sufficient time is provided during training for trainees to discover correct answers or movement patterns (Anderson & Faust, 1973; Pressley, Snyder, & Cariglia-Bull, 1987). Discovery procedures also tend to be associated with greater trainee motivation to study (Kersh, 1962).

Because guidance promotes learning (or at least performance during training) and discovery promotes transfer, the RC trainer should probably employ a combination of both procedures (Aagard & Braby, 1976; Brooks & Dansareau, 1987; Mouly, 1982). Aagard and Braby (1976), for example, suggest that guidance procedures should be used at the start of training and then withdrawn later in a way similar to that recommended above for the use of augmented feedback. That is, guide or prompt trainee responses early in training and later remove the guides to match the level of inherent cues present in the operational task. When trainees give an incorrect response, the trainer should ask a simpler question, provide a hint that will guide trainees to the correct answer, or give trainees the process or rule to be used in determining the answer. Thus, incorrect answers or responses are best handled by helping trainees arrive at a correct answer on their own with guidance applied early in the training session if the correct answers or movements are not forthcoming. Giving trainees the correct answer or physically helping them to make a required movement throughout training is not recommended (Spears, Maxey, & Roush, 1980).

## Testing During Training

Training generally consists of study segments, where trainees are presented with the information or movement to be learned, and test segments where trainees attempt to recall (reproduce) the information or movement from memory. Testing is usually conducted during training for two reasons: to motivate trainees to study and to evaluate or assess how much they have learned. A third reason for testing, i.e., to enhance retention, has gone relatively unnoticed by the military training community.

Although study segments tend to promote acquisition, test segments tend to promote retention (e.g., Hagman, 1981; Izawa, 1970). The beneficial effect of testing on retention was documented early in this century (e.g., Gates, 1917), but has been substantiated and extended primarily over the last two decades. Nungester and Duchastal (1982) conclude that taking a test immediately after learning will lead to better retention even when no further study of the material occurs.

The retention benefit associated with testing is quite reliable and found with rote verbal material (e.g., Allen, Mahler, & Estes, 1969; Hogan &

Kintsch, 1971; Roediger & Payne, 1982; Thompson, Wenger, & Bartling, 1978, Experiment 4), text passages (e.g., Foos & Fisher, 1988; Nungester & Duchastal, 1982), and perceptual-motor tasks (Hagman, 1981, 1983; Hagman & Brosvic, in preparation).

In studying the long-term retention of verbal paired-associates, Allen et al., (1969), for example, found that an immediate test trial, performed after 10 paired stimulus and response study trials, reduced error frequency nearly 50% as compared to 10 paired study trials without the test trial. In addition, long-term retention, as measured by response times and errors, showed further improvement when five test trials were introduced prior to the final retention test.

Hagman (1983, Exp 2) revealed the long-term retention benefits of test trials for the perceptual-motor task of linear positioning. Three groups of 15 government employees either repeated or alternated study and test trials while being trained to reproduce (recall) the end-location of straight, horizontal arm movements. During study trials, employees performed the to-be-learned criterion movement end-location by moving a sliding mechanism along a linear track until contacting a physical stop which was prepositioned by the experimenter at the criterion end-location. During test trials, employees attempted to reproduce the criterion end-location from memory with the stop removed. Recall accuracy associated with each training method was compared during learning and after retention intervals of 3 min and 24 hr. The training sequence for each group consisted of 18 trials divided into 3 cycles of 6 trials each. Cycles contained both study and test trials, but differed in terms of their number and sequence. Figure 10 shows the trials performed in each cycle by each training method group.

| | | | | | | | | Learning Trials | | | | | | | | | Retention Trials | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cycle 1 | | | | | Cycle 2 | | | | Cycle 3 | | | | | | |
| Training Group | 1 | 2 | 3 | 4 | 5 | 6/7 | 8 | 9 | 10 | 11 | 12/13 | 14 | 15 | 16 | 17 | 18/ | 3min | 24hr |
| Study/Test | S | T | S | T | S | T S | T | S | T | S | T S | T | S | T | S | T | T | T |
| Test | S | T | T | T | T | T S | T | T | T | T | T S | T | T | T | T | T | T | T |
| Study | S | S | S | S | S | T S | S | S | S | S | T S | S | S | S | S | T | T | T |

Figure 10. Learning and retention trial sequence for each training method group (S = Study; T = Test). From "Presentation- and Test-Trial Effects on Acquisition and Retention of Distance and Location" by J. D. Hagman, 1983, *Journal of Experimental Psychology: Learning, Memory and Cognition*, *9*, p. 336. Copyright 1983 by the American Psychological Association, Inc. Adapted by permission.

The left side of Figure 11 shows the mean absolute (unsigned) error recall scores for learning test trials; the right side depicts the mean recall

scores for retention test trials. The learning data revealed that end-location recall was more accurate when study trials were repeated or alternated with test trials during training than when test trials were repeated. This was particularly evident when recall was compared at end-of-cycle test trials (i.e., Trials 6, 12, and 18). In contrast, the retention data revealed that study-trial repetition and study- and test-trial alternation resulted in rapid and extensive forgetting, whereas test-trial repetition did not. Consequently, test-trial repetition produced the best retention 24 hr after training. Thus, the retention of simple perceptual-motor tasks can be improved by emphasizing testing during training, at least when these tasks are not job aided (Hagman & Schendel, 1981). In general, Slamecka and McElree (1983) have concluded that testing is one of the few ways of reducing the rate of forgetting over intervals of no practice. Presumably, this is because trainees will tend to remember information or movements that they have generated during recall better than those merely presented during study (Hagman, 1983; Klee & Gardiner, 1976).

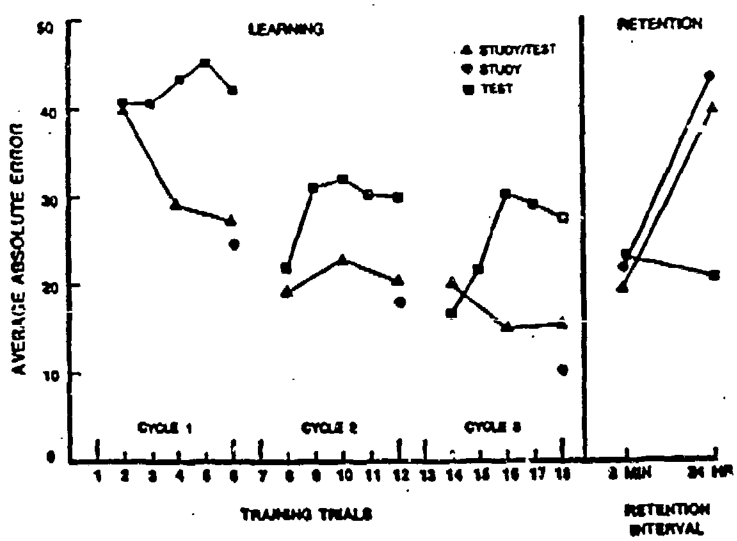


Figure 11. Average Test scores at learning and retention trials performed by each training method group. From "Presentation- and Test-Trial Effects on Acquisition and Retention of Distance and Location" by J. D. Hagman, 1983, Journal of Experimental Psychology: Learning, Memory and Cognition, 9, p. 339. Copyright 1983 by the American Psychological Association, Inc. Adapted by permission.

What proportion of training trials should be study-trials and what proportion should be test trials? Although a definitive answer to this question is not possible for every kind of task, research with verbal paired-associates (Izawa, 1970) and linear positioning movements (Hagman & Brosvic, in preparation) suggests that benefits derived from testing reach a maximum level when 7 consecutive test trials are performed after each study trial.

Emphasized testing is a particularly attractive procedure for application within the RC training environment because a shift in emphasis from study trials to test trials can be accomplished without increases in training time or other associated resources (Hagman & Rose, 1983). Which kind of trial to emphasize, however, should depend on the anticipated length of no-practice

time between the end of training and start of the job. If this interval is long, e.g., a month or more, then testing should be emphasized during training in order to promote retention and ensure that trainees start their jobs at a reasonable level of task proficiency. If trainees will begin their jobs soon after training, then repeated study trials should be emphasized during training to ensure a high level of learning and job-task proficiency.

### Test Expectation

Even the expectation that a test will be given will promote retention over and above that found when a test is not expected (Foos & Clark, 1983). Presumably, trainees study differently as a function of if and how they think they will be evaluated, e.g., perhaps they pay more attention to the task to be learned or organize the materials differently (e.g., Neely & Balota, 1981) when a certain type of test is expected. Schmidt (1983), for example, found that trainees remember information in greater detail when they expect to be tested via recall as opposed to recognition. Test expectation followed by actual testing, however, still produces the best retention, even though trainees seem to prefer test-free training (Halpin & Halpin, 1982).

### Type of Test

To achieve effective retention within the RC training environment, tests should reflect the same memory requirements demanded on the job. If, on the one hand, the job requires recall of information from memory (e.g., no job aid is available) such as in disassembly/assembly of the M16 Rifle, then a test requiring recall (e.g., short answer, fill in the blank, essay, or actual hands-on performance) should be used during training. If, on the other hand, the job requires recognition or identification of information (e.g., vehicle recognition, then a recognition test (e.g., multiple choice) should be used during training (Tversky, 1973).

If job performance conditions are unknown or recall and recognition demands vary from task to task, then the RC trainer should use recall tests throughout training, just to be on the safe side. Recall tests demand the storage of more complete information in order to support the retrieval of the correct response from memory, whereas recognition tests require discrimination of correct from incorrect responses already provided, and thus, can be based on partial or more sketchy information (e.g., Sanjivamurthy & Kumar, 1983). The net effect is that preparation for recall testing will usually support the discrimination requirements of recognition, but preparation for recognition testing will not necessarily support the more stringent retrieval requirements of recall (e.g., Loftus, 1971).

## Adjunct Questions

Adjunct questions are questions that are inserted into the materials to be learned, and therefore, differ from casual questions asked by trainees during classroom discussion or practical exercises, and formal examination questions presented after training is over (Andre, 1979). Adjunct questions benefit learning and retention, presumably because they help trainees to (a) focus attention on critical facts, concepts, or relationships to be learned, and (b) process information in more effective ways during training. Because RC soldiers often opt to rely on nonresident training methods to fulfill

professional development requirements, use of adjunct questions would be particularly appropriate in conjunction with correspondence materials which are typically presented in textual format.

Learning and retention benefits derived from adjunct questions depend upon their location in the text, format, and cognitive level, e.g., whether they require verbatim recall or synthesis and elaboration (Andre, 1979). They also seem to help some trainees more than others.

## Location

Adjunct questions can be positioned either before (prequestions) or after (postquestions) the material they relate to. This location affects the kind of learning that occurs during training. Prequestions primarily facilitate intentional learning, i.e., the learning of information designated by the trainer or instructor as essential for the demonstration of task proficiency (Felker & Dapra, 1975; Rickards, 1979; Sagaria & DiVesta, 1978). Postquestions aid intentional learning too, but unlike prequestions, are more likely to also encourage incidental or unintentional learning (Hamaker, 1986; Rickards, 1979; Snowman & Cunningham, 1975) of information not directly related to specific questions but potentially useful for task applications in other situations. Prequestions depress incidental learning because they tend to reduce learning to a "search task" in which trainees attempt to learn only the information relevant to the specific questions asked (Hamaker, 1986).

If a decision is made to use postquestions during training, a couple of additional research findings will help to enhance their effective application. First, asking one question after each paragraph of text is superior to massing the questions at the end of an entire passage (Frase, 1968). And second, asking a question after two paragraphs is better than asking it after one or four paragraphs (Frase, 1967).

## Cognitive Level

Cognitive level refers to the kind of thinking required to successfully answer the question being asked. Lower level questions require little elaboration or mental manipulation of the material under question (Andre, 1979), e.g., simple recognition of textual information which the adjunct question repeats in either verbatim or paraphrased format, such as "What is the capital of Oregon?". In contrast, higher order questions require trainees to mentally manipulate information previously learned in order to create or support an answer with logically reasoned evidence (Winne, 1979), such as "Which of the following choices is a correct conclusion based on the paragraph you just read?" (Hamilton, 1985).

Lower order questions encourage learning of factual information (Hamaker, 1986), whereas higher order questions encourage learning of both factual and conceptual information. The latter holds true for both prequestions (Wilhite, 1983) and postquestions (Andre, 1979; Friedman & Rickards, 1981).

## Format

Adjunct questions are usually asked in multiple-choice, short answer, or fill-in-the-blank format. Results of past research suggest that learning is

influenced by the type and consistency of format used. Anderson and Biddle (1975), for example, have shown that questions presented in short-answer format are up to two and a half times more effective than questions presented in multiple-choice format. In addition, regardless of the kind of questions, their effect is enhanced if the same format is used for both adjunct and final exam questions (Andre & Womack, 1978; Felker & Dapra, 1975; Hamilton, 1985). And finally, it is important for the RC trainer to ensure that adjunct questions are not too difficult, because they can actually depress learning by increasing frustration and lowering trainee motivation (Andre, 1979).

## Trainee Characteristics

Adjunct questions, especially higher-level ones, will be of maximum benefit for trainees who are either less verbally skilled or who have difficulty comprehending the material to be learned (Andre & Womack, 1978; Rickards & Denner, 1978). Verbally skilled trainees are capable of learning the major organizational features of text on their own, whereas less verbally skilled trainees benefit from aids like adjunct questions to reach a comparable level of proficiency.

Use of adjunct questions will also be more beneficial for trainees with low motivation to learn. Less motivated trainees will benefit from adjunct questions because they help focus attention on specific information to be learned, thereby reducing the effort required to identify this information during training. More motivated trainees are less likely to benefit from this focusing effect because their learning goals may already exceed minimum training requirements (Andre, 1979).

## Elaboration and Mnemonics

Elaboration is a mental process in which past information, imagery, or some type of symbolic structure is added to information to be learned and retained (Rohwer, 1980). In general, elaboration provides an effective safeguard against forgetting (e.g., Farr, 1986; Mayer, 1980; Royer & Cable, 1976; Schallert, 1976).

Although many forms of elaboration exist (see Reder, 1980), one particularly common form is the mnemonic. Mnemonics are used to impose meaning or organization on apparently meaningless or arbitrary materials in order to facilitate their retention. Mnemonics exist for remembering such things as numbers (Higbee, 1977), correct spelling (Griffith, 1979), foreign language vocabulary (Atkinson & Raugh, 1975; Bellezza, 1981), names and faces (Lorayne, 1975; McCarty, 1980), text (Bellezza, 1981), times and places (Griffith, 1979), and the reporting of enemy information (Department of the Army, 1987).

Most mnemonic techniques (mnemotechnics) use a combination of elaboration and reduction encoding to improve retention. Elaboration encoding involves adding information beyond what is strictly necessary in order to make the material more memorable. For example, one might use the sentence "Richard of York gains battles in vain" to recall the order of the spectral colors. The initial letter of the words in the sentence provide the initial letters of the colors in the spectrum in the correct order (i.e., red, orange, yellow, green, blue, indigo, and violet).

Reduction encoding involves the stripping away of irrelevant information in order to reduce the amount of material to remember. Reduction encoding is used in the formation of acronyms, for example, where the first letter of each to-be-remembered word is used rather than the entire word itself. In reporting enemy information, for example, soldiers use the acronym "SALUTE" to help them recall the enemies' size, activity, location, unit, time and equipment).

Some of the more commonly used mnemonic techniques (i.e., mnemotechnics) include: the method of loci, the pegword method, acronyms, acrostics, stories, and rhymes. The method of loci involves visualizing to-be-remembered items in familiar locations, such as the rooms in one's house, which act as retrieval cues to support recall of the items stored there. At recall, one simply "walks through" the house retrieving the images mentally stored at each location.

The pegword technique is similar to the method of loci except that numerical pegwords replace familiar locations as the retrieval cues. The most popular and perhaps easiest-to-learn version is called the "one-bun" mnemonic. To use it, the trainees must first memorize rhyme pegwords for the digits 1 through 10, i.e., one is a bun, two is a shoe, three is a tree, four is a door, and so forth. Each to-be-remembered item is then linked by a visual image to the pegword. Pegword techniques have an advantage over the method of loci in that they not only allow the strict serial learning of a list, but also provide for rapid recall of items directly by their precise serial position. Acronyms, acrostics, stories, and rhymes (e.g. 30 days hath September, April, June, and November) are all familiar to us, and thus, require no further explanation.

Most of the research to date suggests that mnemonics can be used successfully to enhance retention. Their relative effectiveness, however, depends on the kind of mnemonic used, who generates it, how often it is used, trainee ability level, and the type of material to be remembered.

## Type of Mnemonic

Use of bizarre images as mnemonics aids long-term retention (Andreoff & Yarmey, 1976; Einstein, McDaniel, & Lackey, 1989) but does not improve short-term retention over and above that found when common images are used (Nappe & Wollen, 1973; Senter & Hoffman, 1976). Although bizarre images result in better long-term retention, they also take more time to generate because of the extensive elaboration and rehearsal required during training (Reder, 1980). More common images, in contrast, take less time to generate and thus speed up training (Hauck, Walsh, & Kroll, 1976).

## Instructor- versus Trainee-Generated Mnemonics

In general, trainee-generated mnemonics are more effective than instructor-generated mnemonics in facilitating long-term retention. (Bobrow & Bower, 1969; Bower & Winzenz, 1970; Garton & Blick, 1974). However, in cases where trainees are young (Danner & Taylor, 1973; Rohwer, 1970), not sufficiently motivated (Griffith, 1979), or demonstrate difficulty in generating mnemonics without assistance (Kibler & Blick, 1972), use of instructor-generated mnemonics is recommended (see Braby, Kincaid, & Aagard,

1978, for more specific guidance on incorporating mnemonics into military training materials).

## Mnemonics and Repetition

Repetition of mnemotechnics during training is recommended for attaining and maintaining their maximum effectiveness (Lorayne & Lucas, 1974). Continued use of the same mnemonic, however, can have an adverse impact in the form of interference. Bellezza (1981), for example, has found that repeated use of the method of loci during the training of multiple sets of items results in proactive interference where previously learned items impede the memorization of new items.

Interference resulting from continued use of a particular mnemonic can be reduced by allowing self-paced training or by requiring trainees to use progressive elaborations of the same mediators (e.g., images) rather than generating new ones for each successive set of training materials (Bower & Reitman, 1972; Senter, 1971). In addition, rather than employing multiple-use mnemonics, such as the method of loci, single-use or ad hoc mnemonics can be used. The latter eliminate interference because they are used to learn only a single set of materials. Development of ad hoc mnemonics, however, is not easy and may require considerable time and creativity on the part of the instructor (Levin, et al., 1980; Bower, 1973). For help in developing ad hoc mnemonics, see Smith (1969).

## Trainee Ability Level

Effective mnemonic usage may be restricted to higher ability level trainees. Griffith and Actkinson (1978) found that only soldiers with General Technical (GT) scores of 110 and above were able to use the peg-word technique effectively. If mnemonics are used with lower ability trainees, it is possible to increase mnemonic effectiveness by providing more practice on how to use mnemonics or by slowing down the presentation rate of the material during training.

## Task Characteristics

Mnemonics are most effective with training materials that are too complex to be learned effectively by rote (Hagman & Rose, 1983). Dressel (1980) compared the relative effectiveness of rote-repetition and mnemonically-enhanced training methods on the retention of 18 sequential steps required to install the M14 antipersonnel mine. An acrostic mnemonic technique was used in the latter, in which the first letter of each successive word in a highly image-creating sentence was the first letter of each successive mine installation step. Two groups of 17 combat engineers (12B MOS) were trained either with or without the mnemonic to a criterion of three correct task performances. Retention was then tested 1 month later. Results showed that retention failed to vary as a function of the training method used. Most soldiers, however, indicated that the task was relatively easy to learn by rote and that the mnemonic was of little additional help. In support of this, Bellezza (1981) suggests that using mnemonics may be no more effective than other training procedures when less than 10 items are to be learned.

Generally speaking, mnemonic usage is more effective when the materials to be learned are concrete and readily imagined (Paivio, 1971). Thus, a list containing words such as dog, house, flower, and banana (easily imaged words) will be easier to learn and remember through mnemonics than a list containing words such as hope, freedom, integrity, and responsibility (not easily imaged words).

Although mnemonics can enhance the long-term retention of many kinds of materials, a major drawback in regard to RC training is that their usage often requires more training time than other more conventional procedures. A training procedure employing a mnemonic device may result in a recall level of 95 percent after an hour of training, whereas another kind of procedure (e.g., rote repetition) may result in a recall level of 60 percent after 15 minutes of training. A decision by the RC trainer regarding which procedure to use will ultimately depend on the level of proficiency desired and the amount of training time available.

## Similarity

The notion of similarity, i.e., the degree to which two tasks share common components, is important for understanding the concept of transfer and for adopting procedures that promote it. The earliest formulation of the relationship between similarity and transfer was Thorndike's (1903) "identical elements" theory, which has been expanded over the last few decades to state that positive transfer is likely to occur when similar elements (stimuli, responses, concepts, procedures, principles, attitudes, etc.) required for performance of the training task, i.e., Task 1, are also required for performance of the transfer task, i.e., Task 2, (Gick & Holyoak, 1987). Much of what is learned on successive tasks, therefore, is the ability to make a certain response or apply a specific concept in the presence of certain stimuli or task conditions. For example, drivers must learn to make a brake depression response in the presence of a red-light stimulus, or gunners must learn to make the correct aiming response when viewing a target stimulus through their sighting apparatus. Generally speaking, the degree to which stimuli and responses are similar on successive tasks will determine the amount and direction (i.e., positive or negative) of transfer obtained.

The effect of similarity on transfer has been examined extensively with both verbal and perceptual-motor tasks. Research findings related to each task category will be addressed, in turn, in the next two sections.

### Verbal Task Transfer

The basic transfer outcomes found for verbal materials are shown in Figure 12 using letters to indicate stimuli and responses of the training (Task 1) and transfer task (Task 2). In general, maximum transfer is found when stimuli and responses on the training and transfer tasks are identical (i.e., when the two tasks are exactly the same). The amount and direction of transfer will change, however, as the stimuli and responses are varied. If stimuli remain identical and the responses are similar, then high positive transfer will occur (Barnes & Underwood, 1959). If responses remain identical and stimuli are similar, then high positive transfer will also occur (Yum, 1931). The combination of identical stimuli and different responses results

in negative transfer (Postman & Stark, 1969), whereas the outcome when responses are identical and stimuli different depends on how difficult the responses are to learn. With difficult responses, transfer is positive (Martin, 1965); with easy responses, transfer is often negative (Postman, 1962). Different responses and stimuli (i.e., essentially different tasks) result in no transfer or possibly slight positive transfer because of some benefits resulting from temporal and postural adjustments as well as some general learning approaches that carry over positively from the learning of one task to another.

Although the above account is conceptually straightforward, difficulty arises when one attempts to apply these laboratory-based predictions to "real-world" tasks. The primary disconnect occurs in trying to identify the stimuli and responses used by the trainee during the learning of complex tasks which may have many potential stimuli and require the performance of multiple, interrelated responses (see Bernstein & Gonzales, 1971). Thus, generalizing the aforementioned transfer principles to all but the simplest of verbal tasks is difficult at best.

| Task 1 | | Task 2 | | Transfer Outcome |
|---|---|---|---|---|
| Stimulus | Response | Stimulus | Response | |
| A | B | A | B | Maximum Positive |
| A | B | A | B' | High Positive |
| A | B | A' | B | High Positive |
| A | B | A | C | Negative |
| A | B | C | B | Positive (if responses are difficult) Negative (if responses are easy) |

Figure 12. Predicted verbal-task transfer outcomes on the basis of stimulus and response similarity on Task 1 and Task 2 (' = similar).

## Perceptual-Motor Task Transfer

For perceptual-motor tasks, positive transfer is often found, but usually in small amounts (Schmidt, 1975; Schmidt & Young, 1986). In contrast, observation of negative transfer depends primarily on how one defines it (Holding, 1965, 1976). On the one hand, if an overall decrement in transfer task performance is required for negative transfer, then the following conclusions are justified: negative transfer is difficult to produce, when produced occurs in negligible amounts, and rapidly converts to positive transfer (Bilodeau & Bilodeau, 1961). On the other hand, if negative transfer is defined in terms of the occurrence of an occasional, intrusive wrong response, then it may become a practical concern. Intrusive errors, even when isolated, can occur within an overall context of positive transfer (Lewis, McAllister, & Adams, 1951). These errors may have serious consequences for the soldier or the equipment he or she is operating. Thus, the pilot who is well experienced with one aircraft may have no problem, relative to a novice pilot, handling the controls of a different aircraft, up to the point where a

fatal error is caused by previously established flight-control responses that are no longer appropriate.

Defining negative transfer in terms of the number of intrusive errors that occur during transfer task performance, Holding (1965, 1976) suggests that (a) maximum positive transfer will occur when the same stimuli and responses are required on the training and transfer tasks, (b) given identical responses, positive transfer will decrease somewhat with decreasing stimulus similarity, (c) different stimuli and different responses will yield zero transfer, (d) different stimuli for the same response will give large positive transfer, and (e) identical stimuli with different, but similar, responses will produce negative transfer.

The primary difference between verbal and perceptual-motor transfer predictions is in the conditions that produce negative transfer. For perceptual-motor tasks, negative transfer is predicted to occur when responses become more similar (up to a point) under identical stimulus conditions. This is because trainees are unable to distinguish between training and transfer task responses, and thus, the two are confused and errors occur during performance of the transfer task [it should be noted, however, that negative transfer also has been found to occur when the response required for Task 2 is the opposite of that learned on Task 1, e.g, Lewis, et al., (1951)]. For verbal tasks, Barnes and Underwood (1959) suggest that positive transfer increases as response similarity increases for successive tasks having identical stimuli because trainees are able to use training task responses as mediators of the transfer task response. This mediation process does not appear to occur for perceptual-motor responses, and thus, different transfer is predicted for the two types of materials.

Different amounts of training, however, have been found to have the same effect on negative transfer of both verbal and perceptual-motor tasks. In general, most negative transfer occurs after small amounts of practice on the training tasks (Gagne & Foster, 1949; Mandler & Heinemann, 1956; Schmidt, 1971; Siipola & Israel, 1933). Thus, in the time-constrained RC training environment, where the trainer must often choose between training many tasks to a minimal degree or fewer tasks to a greater degree, the latter choice would be recommended from a transfer perspective.

## Part- Versus Whole-Task Training

Another choice that an RC trainer must make in attempting to provide both effective and efficient training is whether to require soldiers to practice (a) an entire task from beginning to end (i.e., whole-task training) or (b) individual parts of a task with the intention of integrating the parts later to form the whole task (i.e., part-task training). The relative efficiency of each procedure is compared by measuring the total time or number of training trials required to perform the whole task to a specified criterion. The basic question of interest is whether prior part-task training produces greater positive transfer to whole-task performance than training on the whole task right from the start.

In general, both whole- and part-task training procedures possess advantages and disadvantages, and therefore, neither procedure is always superior to the other. According to Naylor (1962) and Wightman and Lintern

(1984), effective use of each procedure depends upon the task to be trained, characteristics of the trainee, and the training situation itself.

## Task Characteristics

Two important task characteristics are organization and complexity. Organization refers to the interrelationships that exist between task components or parts. A task is organized if its parts blend together into an integrated whole, e.g., sequential joystick manipulations required for aircraft control. A task is unorganized if its parts constitute self-contained independent subdivisions or subtasks, such as those required to perform mechanical maintenance or aircraft cockpit procedures. Task complexity, in contrast, refers to task length (e.g., the number of procedural steps) and the degree to which memorization is required.

Transfer effectiveness of part- versus whole-task training varies as a function of task organization and complexity. For a highly organized task, e.g., a tennis serve, any attempt to divide it up into parts will destroy its continuity, coordination and timing. As a result, whole-task training is recommended at all levels of complexity. For an unorganized task with independent parts or subtasks, an increase in complexity will favor part-task training (Adams & Hufford, 1962; Naylor & Briggs, 1963; Seymour, 1954). In addition, uniform complexity among task parts is needed for whole-task training to be more effective than part-task training. If uniform complexity does not exist, then trainees will allocate little time to the difficult parts and too much time to the easy parts of a task. Part-task training forces a more equitable distribution of practice time over both easy and difficult parts of a task, and thus, should result in better transfer to the whole task later on (Adams, 1987; Ausubel, 1968).

Often times a task, such as learning a list of unrelated terms, may not have any apparent organization. For such tasks, trainees tend to add their own subjective organizational structure (Tulving, 1962). If this structure is not compatible with the underlying structure of the whole task, then interference and negative transfer will result and whole-task training is recommended. Tulving (1966), for example, had two groups of college students learn the same whole list of 36 unrelated words. The experimental group was given 8 prior training trials on 18 of the words from the whole list, whereas the control group was given 8 prior training trials on 18 words not contained on the whole list.

As shown in Figure 13, the experimental group had an early advantage over the control group in learning the whole list, but this advantage was wiped out as training continued and eventually reversed itself in favor of the control group. Apparently, the subjective organization developed during prior part-list learning interfered with the optimal organization and learning of the whole list.

Manipulations that make subjective part-task organization compatible with whole-task organization will reduce negative and promote positive transfer from part- to whole-task training. These manipulations include: (a) informing trainees beforehand of the relationship between part and whole tasks (Wood & Clark, 1969), (b) using categorically blocked rather than randomly presented part-task items (Ornstein, 1970), and (c) using simultaneous rather than

successive part-and whole-task presentation (Elmes, Roediger, Wilkinson, & Greener, 1972). Each of these manipulations allows trainees to organize part-task items into subjective units compatible with whole-task units, thereby promoting effective part- to whole-task transfer.

## Trainee Characteristics

Results of research examining part- versus whole-task training of rifle marksmanship (McGuigan & MacCaslin, 1955) suggest that higher ability trainees perform better under whole- as opposed to part-task training. Trainees with higher experience levels also perform better under whole-task training procedures (Naylor, 1962). Thus, part-task training may be unnecessary or even counterproductive for very able trainees.

## Training Situation

As training continues, learning is increasingly benefited by whole-task practice (Naylor, 1962; Schendel, et al., 1978). This is especially true when trainees construct subjective organizational units during part-task training. As part-task training continues these units become resistant to modification during whole-task training (Elmes, et al., 1972).

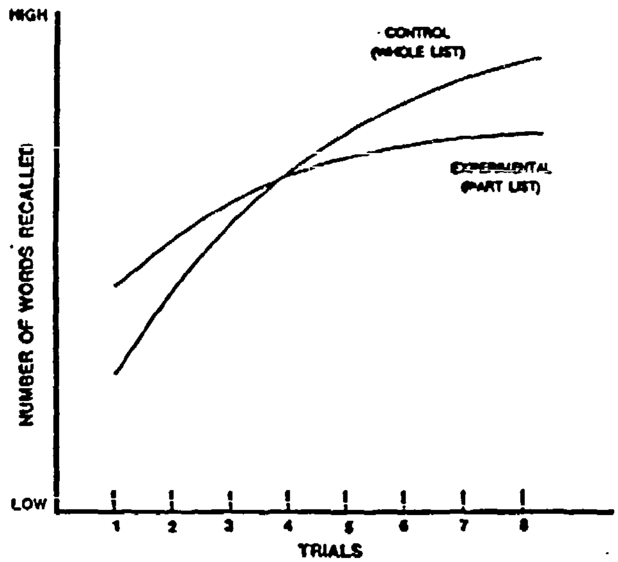


Figure 13. Whole-task learning curves for the experimental (part list) and control (whole list) groups. From "Subjective Organization and Effects of Repetition in Multi-Trial Free-Recall Learning" by E. Tulving, 1966, Journal of Verbal Learning and Verbal Behavior, 5, p. 196. Copyright 1966 by Academic Press, Inc. Adapted by permission.

## Task Variety

Transfer increases with the variety of tasks or examples presented during training (e.g., Hagman, 1980b; Schmidt, 1975; Wheaton, Fingerman, Rose, & Leonard, 1976) provided that the training tasks are sufficiently learned (e.g., Duncan, 1958; Morrisett & Hovland, 1959). This conclusion holds for verbal (Ellis, Parente, Grah, & Spiering, 1975; Baker, Santa, & Gentry, 1977)

as well as perceptual-motor tasks (Kelso & Norman, 1978; Moxley, 1979; Williams & Rodney, 1978).

## Verbal Tasks

Variety is most effective with verbal materials when (a) the training task is structured, e.g., contains an underlying rule, concept, solution, or procedure to be learned (Ellis, Parente, & Walker, 1974; Hunt, Parente, & Ellis, 1974), and (b) the same structure applies to both the training and transfer tasks (Gick & Holyoak, 1987; Hagman, 1980b; Harlow, 1949). For example, Hunt, et al. (1974) trained college students to learn successive sequences of pronounceable trigram doublets (e.g., sumkay, kormel) which were grouped according to four possible configurations, i.e., 2-2-2 (su-mk-ay), 1-4-1 (s-umka-y), 2-3-1 (su-mka-y), 1-3-2 (s-umk-ay). Variability was introduced during training in the form of different grouping rules applied to the same letter sequence on successive training trials. They found that transfer to a subsequent doublet sequence was a function of the degree of variability experienced during training and concluded that variation in the grouping or structure of given letter sequences increases the likelihood of discovering the underlying structure of the to-be-learned materials. The RC trainer should inform trainees of this underlying structure if they do not perceive it on their own (Gick & Holyoak, 1987).

## Perceptual-Motor Tasks

Variety during training will also benefit perceptual-motor task transfer. Typically, research showing this effect has either varied (a) spatial components of the task such as target location (Husak & Reeve, 1979; Kelso & Norman, 1978; Magill & Reeve, 1978, Williams & Rodney, 1978), (b) position of the trainee with respect to a fixed target (Moxley, 1979), or (c) temporal components such as movement time between a constant starting point and target location (Catalano & Kleiner, 1984; Newell & Shapiro, 1976) or movement velocity by varying movement distance and holding movement time constant (Zelaznik, 1977).

The results of these experiments have generally been interpreted as support for the schema theory of learning. As originally formulated by Bartlett (1932) and extended by Schmidt (1975) to motor skills, this theory holds that variability during practice allows trainees to abstract general rules, or schemata, from various sources of movement information (e.g., the present state of the muscular system, sensory consequences of the response, final outcome of the response) that transfer positively to the production of a novel variant of a response not experienced during training. Schema strength, and the likelihood of successful transfer, are primarily a function of the amount of variability experienced during training (Schmidt & Young, 1987).

## Blocked vs Random Ordering

Besides varying tasks during training, it is also possible for the RC trainer to promote retention, as well as transfer, of verbal (Battig, 1972; 1979) and perceptual-motor tasks (Lee & Magill, 1983; Shea & Morgan, 1979; Shea & Zimny, 1983; Wulf & Schmidt, 1988) by varying the order in which tasks are presented. For example, Shea and Morgan (1979) examined the learning of three perceptual-motor tasks (referred to here as A, B, and C) that required

knocking over a series of barriers in a prescribed order as quickly as possible. Each task was defined by a separate pattern of barrier contacts, indicated by a diagram shown to the trainees before the start of each movement. Training involved practicing these movements in either a blocked or random presentation order over a total of 54 trials. Blocked practice required trainees to perform 18 trials of Task A, then 18 trials of Task B, and then 18 trials of Task C. Random practice involved a random ordering of Tasks A, B, and C across the 54 training trials. After training, trainees were tested for retention after no-practice intervals of 10-min and 10-days. They were then also tested for transfer to movement tasks of either the same or greater complexity than the originally learned movements. Results revealed that blocked-order trainees performed better than random-order trainees during training trials, but that the random-order trainees performed better at both retention tests and also demonstrated better transfer, especially to the more complex transfer task.

Drawing on the previous theorizing of Battig (1979) to explain these findings, Shea and Zimny (1983) suggest that random practice produces intertask interference (caused by switching from one movement to another) during training. Learning under such interfering conditions encourages more elaborate processing of movement-related information, and increases distinctiveness among the movements to be learned. This "deeper" processing then results in better retention and transfer (e.g., Craik & Lockhart, 1972).

In contrast, Lee and Magill (1983) argue that random practice during training causes forgetting of the "solution" to the movement problem, so when trainees face the same movement again, a solution must be regenerated, with the regeneration process being important for learning. Trainees with blocked practice can presumably use the solution generated on the previous trial, leading to fewer separate generations and less learning. Whatever the explanation, it is clear that retention and transfer can be improved by adopting a random-order training procedure that requires coverage of multiple tasks over successive training sessions.

Although random practice is a highly effective procedure for promoting retention and transfer, the RC trainer should be aware that it also tends to require a little more time during training to reach initial learning levels comparable to those demonstrated under blocked practice. The extra initial training time needed for random practice, however, would be well invested in terms of reduced refresher training requirements later on.

## Trainee Ability Level

Lastly, research suggests that the beneficial transfer effects accompanying task variety are more pronounced with higher than lower ability trainees (Overton, Lemke, & Williams, 1975), presumably because higher ability trainees are more likely to recognize the underlying structure common to each task variation. Cormier (1987) states that variety facilitates transfer because it allows trainees to identify the stable, underlying aspects of to-be-learned materials and increases the likelihood that these aspects will be retained as a result of being experienced in multiple task situations.

## Task Difficulty

Another question of interest to RC trainers and military course developers is whether training should progress from easy to difficult tasks, or vice versa, to enhance transfer. Although transfer is indeed influenced by differences in difficulty between the training (Task 1) and transfer tasks (Task 2), there is no clear-cut tendency for transfer to always be better from either difficult-to-easy or easy-to-difficult tasks.

In his review of the literature, Holding (1962) suggests that some predictive accuracy regarding transfer between tasks of differing difficulty can be achieved by considering two opposing factors: inclusion and performance standards. In general, transfer will be best in the difficult-to-easy direction when the difficult task includes the easy task, e.g., when training proceeds from general radio repair to output amplifier servicing, or from moving to stationary target firing, and the difficult task is sufficiently learned (Day, 1956). When the difficult task includes all components of the easy task, then no new learning is required when transferring to the easy task. This is not true when training proceeds from easy to difficult (Wheaton, Rose, Fingerman, Korotkin, & Holding, 1976).

Opposing the influence of inclusion is the factor of performance standards. Holding (1962) suggests that if training on an easy task gives rise to errors of relatively small size, and these standards carry over to a more difficult task where a similar error is proportionately smaller, greater transfer will result if training proceeds from difficult to easy. Furthermore, trainees who learn the easy task first may acquire the tendency to prefer accuracy over speed, which will raise their standards of performance in the more difficult task.

In general, the amount of positive transfer obtained during training will depend on the outcome favored in the balance between inclusion and performance standards. The problem is how to determine which tendency outweighs the other. Research to date has not provided practical guidance in this regard.

## Time Interval Between Tasks

Does transfer of training vary as a function of the length of time passing between performance of the training and transfer tasks? Early research found the answer to be "no" (Bunch, 1936; Bunch & McCraven, 1938; Bunch & Lang, 1939), whereas more recent findings suggest that the answer is "it depends." On the one hand, if principles, rules, or general ways of attacking a problem are what is being transferred, then extending the time interval between tasks (within reason) does not appear to make much difference (Ellis & Hunter, 1960, 1961). On the other hand, if memory of specific responses and stimuli is required, then the likelihood of effective transfer will decrease as the time interval between tasks increases because of forgetting (e.g., Ellis & Burnstein, 1960). In addition, in situations where transfer from one task to another is negative, increasing the interval between tasks will reduce the amount of negative transfer through the reduction of intertask interference (Thorndyke & Hayes-Roth, 1979).

Thus, in general, transfer will remain relatively constant over intertask intervals as long as performance of the transfer task does not require memory

for specific items learned during the training task. If item-specific memory is required, then both positive and negative transfer will decrease over time, and there will be a trend toward zero transfer with long intertask intervals. As Gick and Holyoak (1987) point out, however, most transfer experiments minimize the interval between tasks to eliminate the effect of forgetting, and thus, further research is required to determine the validity of the above conclusions with intervals more representative of those experienced by trainees in an operational training environment.

## Verbal to Perceptual-Motor Task Transfer

The fundamental question in this section is whether perceptual-motor learning is facilitated by a prior verbal description of a movement's purpose or of the principles required for its correct execution. According to Cratty (1973), the more accurately a perceptual-motor response can be verbally described, the greater the likelihood that positive transfer will occur.

The degree to which a perceptual-motor task can be verbally described is a function of its complexity. As perceptual-motor tasks become more difficult, verbal description becomes ineffective in communicating the intricacies of the movement required. Success in highly complex perceptual-motor activities is contingent upon precise and rapid kinesthetic regulation rather than upon ideation (Kleinman, 1983). For example, a trainee could be given intensive verbal instruction in the techniques of gymnastics, and yet have no more success in movement execution than an equally able trainee who has not received such prior instruction.

Irion (1966) proposed that the complexity of a movement can be viewed in terms of its availability (e.g., the degree to which it can be performed by the trainee prior to extensive training) and its selectivity (e.g., how precisely it must be performed). Tasks in which high availability is coupled with low selectivity are extremely simple (almost any variation of the response will suffice as correct, e.g., responses like flicking a switch or depressing a button are within almost everyone's capability and can be performed in a variety of ways with the same consequence) and benefit most from verbal pretraining. Conversely, tasks in which low response availability is coupled with high task selectivity benefit very little from verbal pretraining. These tasks require precise responses that involve temporal and spatial coordination rather than ideational factors. Tasks such as high diving, pole vaulting, aiming a rifle, and controlling a joystick have little margin for error, and thus, having the right idea of what is required no longer suffices as evidence for learning.

Overall, the amount of positive verbal-to-motor transfer decreases as the complexity of the perceptual-motor response increases (Granit, 1970). Positive transfer is confined to either extremely simple motor tasks in which high levels of proficiency is not required, or to the earliest stages of training when trainees may rely on verbal mediators to guide responding (Deese & Hulse, 1967).

## Refresher Training

Refresher or sustainment training is an effective procedure for reinstating task proficiency levels and promoting task retention. Time to

refresher train individuals to their original levels of task proficiency is generally rapid, i.e., consistently less than 50% of initial training time (Ammons, Farr, Block, Neumann, Marion, & Ammons, 1958; Mengelkoch, Adams, & Gainer, 1971). The time required for refresher training will vary, however, based on (a) the length of the no-practice interval falling between the end of initial training and the start of refresher training, (b) the frequency of refresher training sessions, (c) the temporal spacing of successive sessions, (d) trainee ability level, and (e) the type of task to be retrained.

Length of No-Practice Interval

Refresher training will take more time the longer it has been since initial training was last conducted. This conclusion is based strictly on the general course of task retention shown in Figure 2. As the no-practice interval increases between initial and refresher training, the amount of task forgetting also increases. Retraining will, therefore, take longer because more forgotten information must be relearned.

Frequency of Sessions

It is generally accepted that the course of learning is typified by an increase in task performance over repetitions provided during initial training, and that losses in the form of forgetting take place after initial training as a result of no practice. Ever since the classic work by Ebbinghaus (1964), it has been known that forgetting is usually not complete unless the no-practice interval is extremely long. Thus, some initially learned information will be retained or "saved" by trainees and applied at a later refresher training session. Because of savings, relearning during refresher training is usually faster than initial learning (Hill, 1914).

Hagman and Wells (in preparation) have shown that task retention increases with the number of prior refresher training sessions completed. This should generally be true provided that forgetting between sessions does not overcome the savings accrued within sessions. As depicted in Figure 14, one can conceive of the learning process as a cycle of learning during training and forgetting during intervals of no practice, with diminishing amounts of information forgotten during no-practice intervals as the number of training or retraining sessions increases. Until finally, the information becomes part of permanent knowledge or memory retrievable without further training. Thus, the need for frequent refresher training will decrease as the number of prior refresher training sessions increases.

Temporal Spacing of Sessions

The amount of savings incurred from prior refresher training sessions will be an inverse function of the temporal interval separating successive sessions, whereas the amount of time required for refresher training will be a direct function of the length of this interval. One way for the RC training to increase refresher training effectiveness, therefore, is to temporally space sessions in close succession to prevent the negative effects of forgetting. Unfortunately, practical limitations on time and the intermittent training schedule (i.e., one weekend drill per month) of RC soldiers, prevent the RC trainer from employing short intersession intervals. Alternative solutions must be sought.

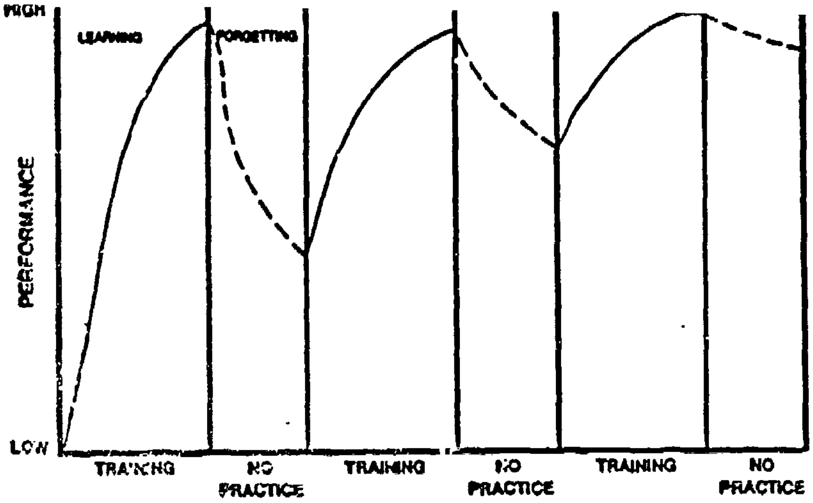


Figure 14: The course of learning and retention over multiple refresher training sessions.

Bahrick (1979, Exp 2) suggests that short intersession intervals may not be absolutely necessary for promoting effective refresher training and associated long-term task retention, at least for cognitive tasks. He had separate groups of college students learn 50 English-Spanish paired associates over six successive refresher training sessions separated by constant intervals of 0, 1, and 30 days. All groups were then tested for retention 30 days after the last refresher training session. Retention improved monotonically over the six refresher training sessions for all groups and the amount of improvement varied inversely with the length of the intersession interval (as hypothesized above). At the 30-day retention test, however, the 0- and 1-day groups showed significant forgetting, whereas the 30-day group did not. Thus, learning was faster with shorter intersession intervals, but retention was better with the longer intersession interval. Bahrick argues that trainees in the 30-day group were able to find out what learning strategies were most effective for remembering information over the 30 days that separated refresher training sessions and change ineffective strategies in anticipation of the 30-day retention test. Trainees in the 0- and 1-day groups, in contrast, had no opportunity to test the effectiveness of their learning strategies for long-term retention prior to taking the 30-day test.

Thus, for maximum effectiveness, refresher training sessions should be scheduled at intervals similar to task usage intervals experienced on the job. If one expects, for example, to recall or use certain information about once a month while on the job, e.g., during monthly RC weekend drill periods, then refresher training should not be scheduled more often than that. Otherwise, tasks may not be learned sufficiently to endure over similar-length, no-practice intervals.

## Trainee Ability Level

Trainees having higher ability levels generally require less time to learn during initial training and to relearn during refresher training (Schendel, et al., 1978). Higher ability trainees (defined in terms of Armed

Forces Qualification Test scores) also have been found to retain more information over intervals of no practice (Vineberg, 1975). As shown in Figure 15, this is not because they forget tasks at a slower rate, but because they learn better initially and this higher level of initial learning results in more information being retained over no-practice intervals (e.g., Carron, 1971; Grimsley, 1969). Thus, given equal amounts of training, higher ability trainees will achieve a higher level of learning than lower ability trainees, demonstrate better retention, and require less frequent refresher training.

To preclude the possibility of giving refresher training to higher ability trainees before it is needed or to lower ability trainees later than it is needed, RC trainers should train all soldiers to a common standard of performance. This will require additional initial training for those of lower ability, but will ensure a common refresher training schedule appropriate for everyone.

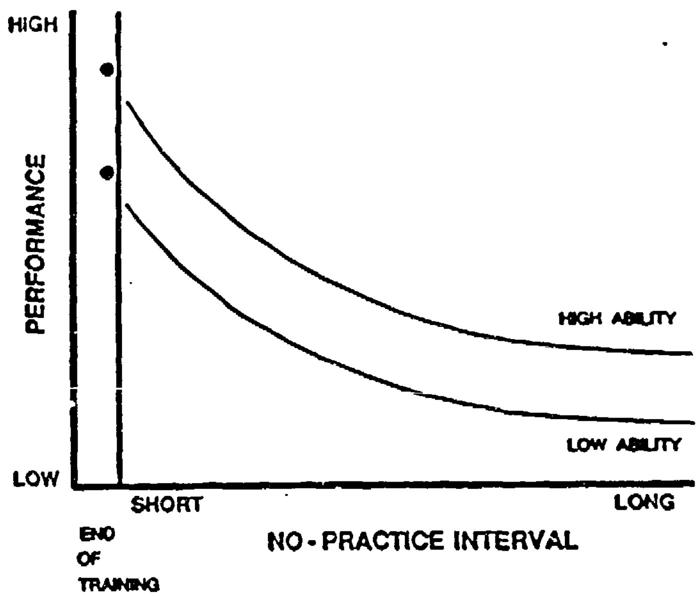


Figure 15. Rate of task forgetting for high- and low-ability trainees.

## Type of Task

All tasks are not forgotten at the same rate and the schedule of required refresher training will vary as a function of the specific tasks involved (Hagman & Rose, 1983). Information about the relative forgetting rates of specific tasks, therefore, is critical for effective and efficient management of scarce RC refresher training resources.

Initial information about how quickly different tasks are forgotten has been provided by Shields, Goldberg, and Dressel (1979). They examined 532 soldiers' retention of 20 common soldier tasks over no-practice intervals ranging from 4 to 12 months following initial basic combat training. Tasks examined included reporting of enemy information, loading and firing the M203 grenade launcher, donning the gas mask, and cardiopulmonary resuscitation. They found that retention, as measured by the percentage of soldiers performing each task correctly (i.e., those receiving a "GO"), declined over time, and that the rate of decline was a function of specific task characteristics. Using stepwise multiple regression analyses, the best

predictor of forgetting rate was found to be the number of steps required by a task. Figure 16 shows this relationship for the four tasks mentioned above. They also found consistencies in the kinds of steps missed across tasks. In general, soldiers forgot steps that were not cued by the equipment or by previous steps, such as those involving safety. If, for example, an M16 rifle was to be disassembled and assembled, soldiers tended to forget the safety step of clearing the weapon.

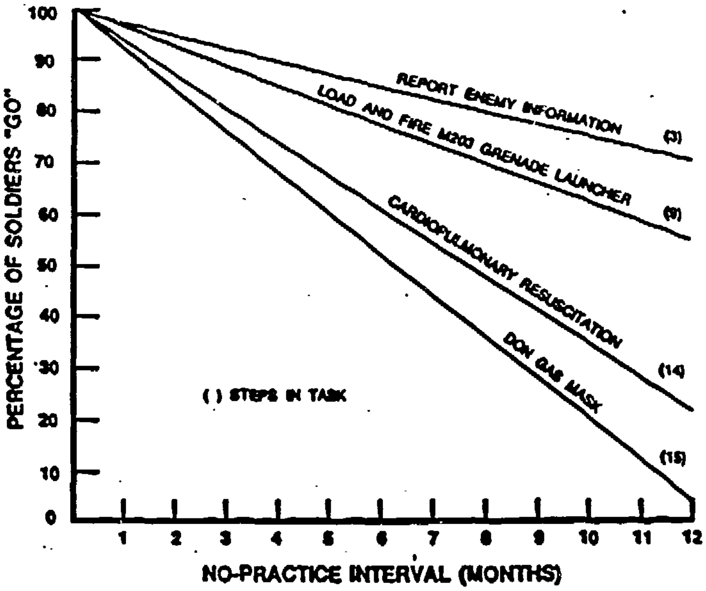


Figure 16. Forgetting rates of four military tasks over 12 months of no practice.

Expanding on the notion that task characteristics can be used to determine forgetting rates, Rose, Czarnolewski, Gragg, Austin, Ford, Doyle, and Hagman (1985) have developed a procedure for predicting the retention of both cognitive and perceptual-motor military tasks over no-practice intervals of up to one year. As described in the associated user's manual (Rose, Radtke, Shettel, & Hagman, 1985) and elsewhere (Hagman, Hayes, & Bierwirth, 1986), the procedure is really quite easy to follow and requires performance of only two basic steps. The first step involves rating each task of interest on how difficult it is to remember. This rating is based on whether or not a task contains specific characteristics known to influence retention. One characteristic, for example, is whether or not a task is job aided, e.g., supported by instructions contained in technical manuals or checklists, or instructions stamped directly on the equipment. Job aids reduce memory load, and thus, a task will be remembered better with a job aid than without it. Another characteristic is task length, as defined by the number of performance steps required. Retention decreases as task length increases (e.g., Shields, et al., 1979), and thus, longer tasks are more difficult to remember than shorter tasks. In all, tasks are rated on a maximum of 10 characteristics (see Table 1) and receive an empirically derived retention rating score from 1 to 220 based on the presence or absence of each characteristic. The lower the rating score, the quicker a specific task will be forgotten.

The second, and final, step involves plugging a task's retention rating score into the retention prediction matrix shown in Table 2. The numbers along the left-hand column of the table are the task retention rating scores

while the numbers along the top row refer to how many months it has been since a task was last practiced (i.e., the no-practice interval). The numbers in the body of the table refer to the percentage of soldiers who will be able to perform the task correctly.

Table 1

Task Characteristics Related to Retention.

- o Job/Memory Aided
- o Length
- o Built-in Logic to Steps
- o Number of Facts
- o Movement Demands
- o Quality of Job/Memory Aids
- o Definite Step Sequence
- o Mental Requirements
- o Complexity of Facts
- o Time Demands

Suppose, for example, that the task "identifying hand grenades" has a retention rating score of 120 and has not been practiced for 2 months. Reading across the "120" row to the column labeled 2 months, it would be predicted that 40% of the soldiers could identify the grenades correctly. Table 3 shows retention rating scores for some additional military tasks.

Table 2

Retention Prediction Matrix.

| Retention Rating Score | Months Since Last Practice | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 180 or more | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 175 | 97 | 96 | 92 | 90 | 87 | 85 | 83 | 81 | 79 | 77 | 75 | 73 |
| 170 | 94 | 90 | 85 | 81 | 76 | 72 | 69 | 65 | 62 | 59 | 56 | 53 |
| 165 | 92 | 85 | 78 | 72 | 66 | 61 | 56 | 52 | 48 | 44 | 40 | 37 |
| 160 | 89 | 80 | 71 | 64 | 57 | 51 | 45 | 40 | 36 | 32 | 29 | 26 |
| 155 | 86 | 75 | 64 | 56 | 48 | 42 | 36 | 31 | 27 | 23 | 20 | 17 |
| 150 | 83 | 70 | 58 | 49 | 40 | 34 | 28 | 24 | 20 | 16 | 14 | 11 |
| 145 | 80 | 66 | 52 | 42 | 34 | 27 | 22 | 17 | 14 | 11 | 9 | 7 |
| 140 | 77 | 60 | 46 | 36 | 27 | 21 | 16 | 12 | 10 | 7 | 6 | 4 |
| 135 | 74 | 55 | 40 | 30 | 22 | 16 | 12 | 9 | 6 | 5 | 3 | 2 |
| 130 | 70 | 50 | 35 | 25 | 17 | 12 | 8 | 6 | 4 | 3 | 2 | 1 |
| 125 | 67 | 45 | 30 | 20 | 13 | 9 | 6 | 4 | 2 | 1 | 1 | 0 |
| 120 | 63 | 40 | 25 | 16 | 10 | 6 | 4 | 2 | 1 | 0 | 0 | 0 |
| 115 | 59 | 35 | 20 | 12 | 7 | 4 | 2 | 1 | 0 | 0 | 0 | 0 |
| 110 | 54 | 29 | 16 | 8 | 4 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| 105 | 50 | 25 | 12 | 6 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100 | 44 | 20 | 8 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 95 | 38 | 15 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 31 | 10 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 85 | 22 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 or less | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Although the above task prediction procedure cannot predict the retention performance of an individual soldier or the mission criticality of a specific task, it can be used to answer important refresher training questions such as (a) how quickly is a specific task forgotten, (b) which tasks are more likely to be forgotten than others, (c) what percentage of the soldiers in a unit will be able to perform a task correctly after up to 1 year of no practice, and (d) when and how often should refresher training be scheduled for maximum payoff.

Table 3

Example Tasks with Ratings.

| Task | Retention Rating Score |
|---|---|
| Perform Operator Maintenance on Goggles | 220 |
| Determine National Stock Number for Repair Part | 195 |
| Move Under Direct Fire | 170 |
| Determine Magnetic Azimuth Using a Compass | 155 |
| Administer First Aid for an Open Abdominal Wound | 140 |
| Identify and Employ Hand Grenades | 120 |
| Live Off the Land | 100 |
| Identify Armored Vehicles | 75 |
| Techniques of Movement in Urban Terrain | 65 |

## Cooperative Training

Although individual training has been the primary area of research interest for many years, there has been a growing interest over the past two decades in the potential use of cooperative or small-group training for improving individual performance (e.g., Sharan, 1980; Slavin, 1980a, 1980b, 1983; Webb, 1984). Under cooperative training, trainees spend all or a portion of their class time working in small groups where they are expected to help one another learn. This is in contrast to individual training where trainees typically are expected to learn on their own with help from an instructor rather than from one another.

Although groups per se generally outperform individuals on a wide variety of laboratory (Laughlin, Kalowski, Metzler, Ostap, & Venclovas, 1968; Ryack, 1965; Wegner & Zeaman, 1965), academic (Edwards, DeVries, & Snyder, 1972; Humphreys, Johnson, & Johnson, 1982; Lew & Bryant, 1981), and technical tasks

(Dossett & Hulvershorn, 1983; Hungerland, Taylor, & Brennan, 1977), this cooperative or small-group training does not necessarily lead to superior individual learning. Sometimes individuals perform better after training in a group (Humphreys, et al., 1982; Slavin & Karweit, 1981); other times they perform better after training on their own (Beane & Lemke, 1971; Laughlin & Sweeney, 1977). Knowledge of conditions under which cooperative training is superior to individual training would not only improve soldier performance, but also help to reduce training problems resulting from limitations in the number qualified trainers present at small, geographically dispersed RC units.

Two conditions appear necessary for obtaining effective individual learning under a cooperative training approach. First, group members must be held individually accountable for their own performance. Each must contribute his or her own best effort toward achieving group success, and this effort must be visible and quantifiable. Requiring accountability from each group member prevents one member from doing all the work and encourages all members to contribute to learning the task at hand (Slavin, 1983). Second, individual group members must be rewarded (e.g., recognized, praised, allowed to proceed with further training) on the basis of their performance as a group. That is, two or more group members must be interdependent for a reward which they will share if successful as a group (Slavin, 1983), e.g., if all members of a group get a "GO," then the group gets a "GO," whereas if one group member fails to get a "GO" then the entire group must get a "NOGO." This kind of group reward structure differs from an individual reward structure where individual groups members are rewarded independently on the basis of their own performance regardless of that of others.

Presumably, group reward is necessary because it encourages group members to interact, share knowledge, and take interest in each other's progress because reward is contingent upon the successful performance of all. This interaction among group members is associated with gains in individual achievement. Interaction in the form of giving and receiving of answers (with explanations) is the best predictor of individual learning on cooperative training tasks, whereas receiving no answer or only an answer without explanation is negatively associated with individual trainee gains (Webb, 1984). Under an individual reward structure, there is no reason for group members to share their knowledge (e.g., tutor one another) because rewards are received on an individual rather than group basis.

An experiment by Hagman and Hayes (1985) has shown the beneficial effects of group reward. They compared test performance of individual trainees following cooperative training under both individual and group reward contingencies. Two hundred and eighty Equipment Records and Parts Specialists (76C MOS) were divided into 6 treatment conditions formed by the combination of two kinds of reward (individual vs group) and three group sizes (1, 2, and 4 members), as shown in Figure 17. Trainees in each condition received lecture-based, classroom instruction on Prescribed Load List procedures (e.g., identification of repair parts, preparation of requests for issue and turn-in of parts, updating of due-in records, receipt and storage of parts, taking parts inventory, etc.) and then broke off into their respective cooperative groups to work on practical exercises.

| | |
|---|---|
| 1 | Individual |
| 2 | Individual |
| 4 | Individual |
| 1 | Group |
| 2 | Group |
| 4 | Group |

Figure 17. Cooperative training treatment conditions.

Trainees worked together in their respective groups to arrive at agreed-upon answers to practical exercise questions and then were tested individually for achieved proficiency. Group members were rewarded either individually or as a group for their individual test performance. Under individual reward, trainees received either a "GO" or "NOGO" based on their individual test scores and were rewarded (i.e., allowed to proceed to the next block of instruction) independently of one another. Any trainee not attaining criterion on a test was required to attend a remedial study hall before taking the test a second time and rejoining his or her fellow groupmates for the next instructional block. Under group reward, group members received either a GO or NOGO based on whether or not all attained the test criterion. If each member was successful, then all were rewarded (i.e., allowed to proceed together to the next instructional block). If one or more members failed to achieve criterion, then all, including those that did reach criterion, returned to study hall to help the failing member(s) restudy for a second attempt at the test.

As shown in Figure 18, the mean number of errors committed as well as test completion times favored trainees working under group reward, especially when groups contained four members. Thus, individual trainees demonstrated

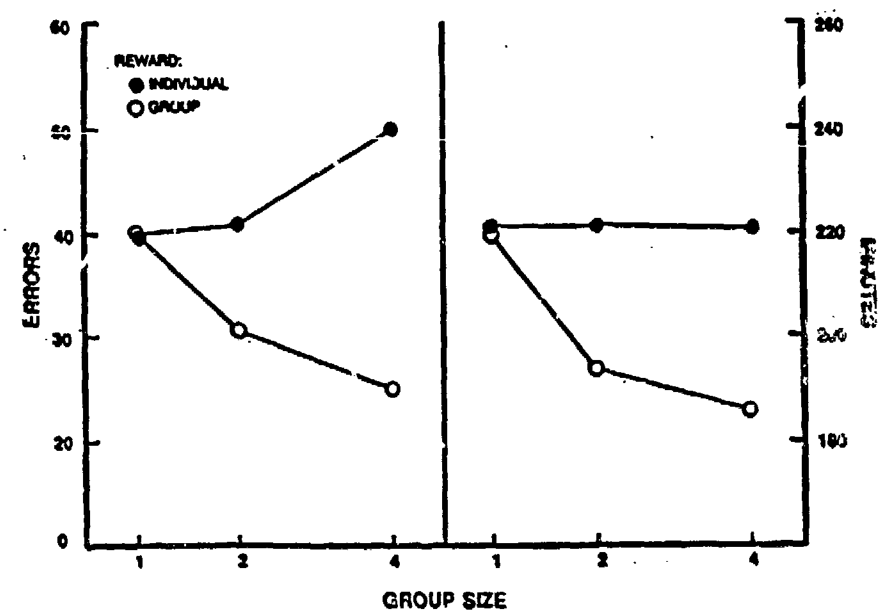


Figure 18. Average error scores and test completion times.

greater accuracy and completed testing faster if they studied together under a group reward contingency. These results were interpreted as support for the argument that group reward promotes trainee interaction in the form of peer tutoring which occurs more under a group reward contingency than under an individual reward contingency (Slavin, 1980a) and which usually has beneficial effects on individual trainee learning (Devin-Sheehan, et al., 1976; Sharan, 1980).

Given that the prerequisite conditions of individual accountability (e.g., trainees are tested individually) and group reward are met, the degree of individual achievement resulting from cooperative training will also be influenced by group factors such ability-level mix, communication strategy, and size.

## Ability-Level Mix

Although the results of research examining how best to assign individuals to groups on the basis of their ability level has been somewhat inconsistent, two general conclusions are possible. First, uniform ability groupings are effective as long as either high ability trainees are paired with other high ability trainees, or medium ability level trainees are paired with other medium ability trainees. The composition to avoid is low ability trainees grouped with other low ability trainees (Berkowitz & Szabo, 1977). And second, medium ability trainees should be grouped with trainees of at least comparable ability. If both high and low ability trainees are grouped with medium ability trainees, the latter tend to be left out of the discussion (Webb, 1982). These conclusions hold for trainees with little or no experience with cooperative training programs, but may not apply to experienced trainees (Webb, 1984).

## Communication Strategy

Dansereau (1983) has shown that predesigned group communication procedures promote better individual learning than procedures adopted by groups when left on their own. One such procedure used for the learning of textual material involves having one member of a group recall and summarize the to-be-learned information and having the other(s) critique and elaborate upon the summary (Brooks & Dansereau, 1987). Although this kind of procedure tends to benefit the recalling member more than the critiquing member(s), both benefit more than members of groups that do not adopt such a procedure. Furthermore, it is always possible to spread these benefits around by distributing the responsibilities for recalling and critiquing to each group member (Spurlin, Dansereau, Larson, & Brooks, 1984).

## Group Size

Generally speaking, group performance improves as group size increases (Hill, 1982). According to Steiner's (1966) complementary task model, performance varies directly with group size because each group member has knowledge not possessed by others. The probability of a correct response, therefore, goes up as this knowledge pool increases with group membership (Laughlin, Branch, & Johnson, 1969) provided that members are willing to communicate with one another. Although some individual learning benefits are certainly possible with two-member groups (e.g., Dossett & Hulvershorn, 1983),

greater benefits can be expected with four-member groups (Hagman & Hayes, 1985). Once group size reaches six members, however, "social loafing" may occur (Latane, Williams, & Harkins, 1979) and each member may not put forth his or her own best effort. Thus, the RC trainer expect greater trainee satisfaction and involvement with groups containing three to six members than with groups containing more than six members.

## Summary

This report was written to provide the U.S. Army National Guard and Reserve, i.e., the RC, with (a) a practicable information base to support decisions about how soldier performance could be enhanced through the use of specific training procedures, and (b) empirically based guidelines for improving the learning, retention, and transfer of military tasks.

The effects of a broad range of general training procedures applicable to the unique RC training environment are discussed. Many of the conclusions reached are based on the results of both basic (laboratory) and applied (field) research and are somewhat oversimplified to promote understanding and application.

These constraints notwithstanding, the following general conclusions can be made:

1. Pretraining procedures that incorporate the use of pretests, behavioral objectives, overviews, or advance organizers enhance the learning process. Pretests alert, behavioral objectives inform, overviews prepare, and advance organizers clarify. All give direction and purpose to learning through their introductory or anticipatory role and provide an overall learning set for what is to follow.

2. Once training begins, repetition is necessary to achieve proficiency on all but the simplest of verbal and perceptual-motor tasks. Providing additional repetitions beyond those necessary for achieving minimum task proficiency will promote further learning, increase retention, and reduce the need for frequent refresher training. Transfer will also improve as the number of repetitions is increased, especially when task variety is emphasized.

3. Retention of verbal tasks is better when repetitions are spaced (e.g., separated in time) than when they are massed (e.g., performed in succession without an intervening time interval). Benefits from spacing increase as the interval between repetitions increases, provided this interval is not excessive.

4. Massed and spaced repetition schedules seem to have about the same beneficial effect on the retention of perceptual-motor tasks. Spaced scheduling is particularly recommended for (a) dangerous tasks where fatigue could pose a safety risk, (b) poorly motivated trainees who are adversely affected by the rigorous nature of massed repetitions, and (c) high-ability trainees who tend to make more responses during massed scheduling, quickly become fatigued, and accordingly respond at a lower level of proficiency than trainees of lower ability. The need for additional training time under a spaced repetition procedure can be eliminated through task alternation.

5. Mental practice is effective for learning both verbal and perceptual-motor tasks. For the latter, the most effective procedure probably involves a combination of both physical and mental practice. Benefits from mental practice are more likely to occur early in training when verbal-cognitive processes are most involved, but also can occur later or when trainees are more capable of conceptualizing responses mentally. Mental practice sessions should be kept brief (e.g., 5 min or less) in order for trainees to maintain effective concentration.

6. Benefits derived from repetition can be enhanced if trainees also intend to learn the task. This intent should be present before training starts and can be established by (a) assisting trainees in setting performance goals, and (b) indicating the future utility of the task to be learned.

7. Knowledge of results (KR) is essential for achieving effective learning, retention, and transfer. The benefits of providing KR depend upon the (a) length of time passing between a response and receipt of KR, (b) amount of time passing between KR and the next response, (c) precision of KR, (d) frequency of KR, and (e) if and when KR is withdrawn during training.

8. The more response-produced feedback (i.e., sensations accompanying a response) provided during training, the more accurate and confident trainees' responses will become. The most important feedback channel is vision.

9. Providing augmented feedback (i.e., artificial cues not normally associated with response production) improves performance and speeds up training. These benefits, however, can be transitory and may not persist once the cues are removed unless an adaptive withdrawal procedure is used wherein augmented feedback is given only when responses exceed a specific error limit or significantly deviate off course.

10. Guidance during training (e.g., in the form of telling or physically showing trainees the correct response) will promote quicker and more accurate learning of the specific task being trained. In contrast, encouraging trainees to discover the correct response on their own, usually through a process of trial and error (with KR), typically promotes better transfer of learning from one task to another. Training that initially provides guidance at the start and then switches later on to discovery will promote effective learning, retention, and transfer.

11. Testing should be emphasized during training to promote effective verbal and perceptual-motor task retention. The type of test used should reflect job conditions. Recall tests usually will support the discrimination requirements of a recognition test, but recognition tests will not necessarily support the more stringent memory retrieval requirements of a recall test.

12. Questions should be asked within the context of the training materials to enhance learning and retention. Benefits achieved from asking questions will vary as a function of (a) their location in the text, (b) the kinds of questions asked, and (c) their format.

13. Learning and retention increase when trainees are required to elaborate on the materials to be learned. Elaboration can take the form of adding related background information, imagery, or any kind of symbolic

structure to the training materials for the purpose of making them more memorable. A common form of elaboration involves the use of mnemonics. Mnemonics are most effective when the material to be learned is concrete (easily imagined), and when it is not easily learned through rote repetition. Although mnemonic usage can improve retention, it often also increases the time required for training.

14. Positive transfer is likely to occur when similar elements (e.g., stimuli, responses, concepts, procedures, rules, etc.) are present in both the training and transfer task(s). The degree of intertask similarity will determine how much and what kind of transfer (positive or negative) is obtained with both verbal and perceptual-motor tasks.

15. Whole-task training is recommended for tasks that require continuity and coordination of their various parts, whereas part-task training is recommended for tasks that are difficult to perform and consist of independent parts or subtasks.

16. Transfer of verbal and perceptual-task learning increases with the variety of tasks (or examples) presented during training, provided that each task is sufficiently learned. Task variety should be presented in a random rather than a blocked order to promote maximum retention and transfer.

17. The time interval between the performance of successive tasks should be kept to a minimum to ensure effective transfer.

18. Providing a verbal description of a perceptual-motor response or movement will improve learning and retention, provided that the required response does not depend largely on precise proprioceptive regulation.

19. Refresher or sustainment training is an effective procedure for reinstating task proficiency levels and promoting long-term retention. The amount of time required for refresher training is typically less than that required for initial training but will vary as a function of the (a) length of the no-practice interval intervening between the end of initial training and the start of refresher training, (b) the frequency of prior refresher training sessions, (c) the temporal spacing of sessions, and (d) the type of task to be retrained. A method for predicting task retention and associated refresher training requirements is discussed in the body of the report.

20. Cooperative or small-group training is an effective procedure for improving individual trainee achievement, provided each group member is held individually accountable (i.e., tested) for his or her own learning and a group reward contingency is enforced. Benefits from cooperative learning will be most pronounced with groups containing six or less members.

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